Savannah River Site
Solid Waste Management Department
Consolidated Incinerator Facility
Operator Training Program

ELECTRICAL DISTRIBUTION (U)

Study Guide

ZIOITX06.01

Revision 02

Training Manager / Date

Engineering Manager / Date

Facility Manager / Date

FOR TRAINING USE ONLY

The uncontrolled information contained in these training materials is FOR TRAINING USE ONLY. In no way should it be interpreted that the material contained herein may be substituted for facility procedures. Where copies of procedures are given, they are intended as examples and information only, and the latest revision of the material in question should be obtained for actual use. If you have any questions, contact your supervisor.

REVISION LOG

REV.	AFFECTED SECTION(S)	SUMMARY OF CHANGE
02	All	Objectives modified, and updated to CIF format. Added discussions of major components, instrumentation and controls. Added references to Lessons Learned, DCS/PLC alarm interfaces..

REFERENCES

1. Savannah River Site Consolidated Incineration Facility Functional Description, *Facility Electrical Power System,* Rev. 1

2. Savannah River Site Solid Waste Training System Design Description, *Electrical System,* Rev. 0

3. Savannah River Site Consolidated Incineration Facility, *Safety Analysis Review,* DOE Review Draft

4. Savannah River Site Manual 8Q, *Employee Safety Manual*.

5. 261-SOP-ELLV-01, *208/120 Volt Power,* Rev. 2

6. 261-SOP-ELNA-01, *kV/480 Volt Substation*, Rev. 2

7. 261-SOP-ELNH-01, *480 Volt Power Electrical*, Rev. 4

8. 261-SOP-UPS-01, *Uninterruptable Power Supply and Instrument Power Operation,* Rev. 3

9. 261-SUR-UPS-01, *Uninterruptable Power Supply Quarterly Test,* Rev. 0-E

10. D844136, *CIF 13.8KV/480V Substation Coordination Curves*

11. W830395 Rev. 3, Savannah River Site, Building 261-H, Consolidated Incineration Facility Single Line Diagram, *480V Substation Electrical (U)*

12. W830399, Rev. 5, Savannah River Site, Building 261-H, Consolidated Incineration Facility Single Line Diagram, *MCC-1 Electrical(U)*

13. W830400, Rev. 4, Savannah River Site, Building 261-H, Consolidated Incineration Facility Single Line Diagram, *MCC-2 Electrical(U)*

14. W830401, Rev. 7, Savannah River Site, Building 261-H, Consolidated Incineration Facility Single Line Diagram, *MCC-3 Electrical(U)*

15. WI30402, Rev. 7, Savannah River Site, Building 261-H, Consolidated Incineration Facility Single Line Diagram, *MCC-4 Electrical(U)*

16. W830403, Rev. 3, Savannah River Site, Building 261-H, Consolidated Incineration Facility Single Line Diagram, *MCC-5 Electrical(U)*

17. W830404, Rev. 6, Savannah River Site, Building 261-H, Consolidated Incineration Facility Single Line Diagram, *MCC-6 Electrical(U)*

18. W830405, Rev. 7, Savannah River Site, Building 261-H, Consolidated Incineration Facility Single Line Diagram, *MCC-7 Electrical(U)*

19. W830406, Rev. 9, Savannah River Site, Building 261-H, Consolidated Incineration Facility Single Line Diagram, *MCC-8 Electrical(U)*

20. W833053, Rev. 2, Savannah River Site, Building 262-H, Consolidated Incineration Facility, *Tank Farm Motor Schematic SH1 Electrical(U)*

21. W833054, Rev. 4, Savannah River Site, Building 262-H, Consolidated Incineration Facility, *Tank Farm Motor Schematic SH2 Electrical(U)*

22. W833055, Rev. 4, Savannah River Site, Building 262-H, Consolidated Incineration Facility, *Tank Farm Motor Schematic SH3 Electrical(U)*

23. W833056, Rev. 2, Savannah River Site, Building 262-H, Consolidated Incineration Facility, *Tank Farm Motor Schematic SH4 Electrical(U)*

24. W833057, Rev. 3, Savannah River Site, Building 262-H, Consolidated Incineration Facility, *Tank Farm Motor Schematic SH5 Electrical(U)*

25. W833058, Rev. 3 , Savannah River Site, Building 262-H, Consolidated Incineration Facility, *Tank Farm Motor Schematic SH6 Electrical(U)*

26. W833059, Rev. 2, Savannah River Site, Building 262-H, Consolidated Incineration Facility, *Tank Farm Motor Schematic SH7 Electrical(U)*

27. W833060, Rev. 2, Savannah River Site, Building 262-H, Consolidated Incineration Facility, *Tank Farm Motor Schematic SH8 Electrical(U)*

28. W833093, Rev. 1, Savannah River Site, Building 261-H, Consolidated Incineration Facility, *Off Gas System Motor Schematic SH1 Electrical(U)*

29. W833094, Rev. 1, Savannah River Site, Building 261-H, Consolidated Incineration Facility, *Off Gas System Motor Schematic SH2 Electrical(U)*

30. W833095, Rev. 1, Savannah River Site, Building 261-H, Consolidated Incineration Facility, *Off Gas System Motor Schematic SH3 Electrical(U)*

31. W833096, Rev. 1, Savannah River Site, Building 261-H, Consolidated Incineration Facility, *Off Gas System Motor Schematic SH4 Electrical(U)*

32. W833097, Rev. 1, Savannah River Site, Building 261-H, Consolidated Incineration Facility, *Off Gas System Motor Schematic SH5 Electrical(U)*

33. W833098, Rev. 1, Savannah River Site, Building 261-H, Consolidated Incineration Facility, *Off Gas System Motor Schematic SH6 Electrical(U)*

34. W833099, Rev. 1, Savannah River Site, Building 261-H, Consolidated Incineration Facility, *Off Gas System Motor Schematic SH7 Electrical(U)*

35. W833100, Rev. 2, Savannah River Site, Building 261-H, Consolidated Incineration Facility, *Off Gas System Motor Schematic SH8 Electrical(U)*

37 W836256, *13.8KV Single Line Distribution Diagram*

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LEARNING OBJECTIVES

TERMINAL OBJECTIVE

1.0 Without references, **EXPLAIN** the significance of the Electrical Distribution system to Consolidated Incinerator Facility operations, including its importance to safety, and the impact on operations of a failure of the system.

ENABLING LEARNING OBJECTIVES

1.1 **DESCRIBE** the hazards associated with electrical equipment. Include the effects to the human body of receiving an electrical shock at the following current values:

a. 1 milliamp
b. 10 milliamps
c. 50 milliamps
d. 100 milliamps

1.2 **DESCRIBE** the personnel safety concerns associated with the Electrical Distribution System.

1.3 **DEFINE** the following electrical terms:

a. Area substation
b. Transformer
c. Distribution substation
d. Motor Control Center (MCC)
e. Automatic Transfer Switch (ATS)
f. Contactor
g. Motor starter
h. Panel board
1. Circuit breaker
j. MCC Switch and fuses
k. Disconnect switch, safety switch, manual transfer switch
l. Tie-breaker, main breaker, feeder breaker, switchgear
m. Normal power/multiple sources
n. Alternate power
o. Standby diesel generator power
p. Vital/Essential load
q. Electrical fault

ENABLING LEARNING OBJECTIVES

1.4 **STATE** the purposes of the Electrical Distribution System.

1.5 Briefly **DESCRIBE** how the Electrical Distribution System accomplishes its intended purpose.

1.6 **EXPLAIN** the consequences of a failure of the Electrical Distribution System to fulfill its intended purpose, including the effects on other systems or components, overall plant operation, and safety.

TERMINAL OBJECTIVE

2.0 Using system diagrams, **EVALUATE** potential problems which could interfere with normal Electrical Distribution System flowpaths to determine their significance on overall system operation and the corrective actions needed to return the system to normal.

2.1 With the aid of a site Electrical Distribution one-line diagram, **IDENTIFY** the source of power and system voltage supplied to the H Area.

2.2 **IDENTIFY** all sources of power that supply the site distribution system and **IDENTIFY** the voltage levels of the sources.

2.3 Using an electrical schematic drawing of the H Area (251-H) main substation, **STATE** the source of electrical power and system voltage that supports the CIF Substation at Building 261-H.

2.4 **DESCRIBE** the physical layout of the Electrical Distribution System components including the general location, how many there are, and functional relationship for each of the following major components:

a. 261-H Substation
b. Automatic Transfer Switches (ATS)
c. Standby Diesel Generators (SDG)
d. Motor Control Centers (MCC)
e. Uninterruptable Power Supply (UPS)
f. Safety Switches
j. 480 VAC to 120/208 VAC transformers
h. Panel boards
I. Variable speed drives

2.5 **DESCRIBE** the Electrical Distribution System arrangement to include a single-line drawing showing the following system components and interfaces with other electrical system components:

a. 261-H Substation
b. Automatic Transfer Switches (ATS)
c. Standby Diesel Generators (SDG)
d. Motor Control Centers (MCC)
e. Uninterruptable Power Supply (UPS)
f. Safety Switches
j. 480 VAC to 120/208 VAC transformers
h. Panel boards
I. Variable speed drives

2.6 Given a description of the Electrical Distribution System equipment status, **IDENTIFY** conditions which interfere with normal system flowpaths.:

2.7 Given a description of abnormal equipment status for the Electrical Distribution System, **EXPLAIN** the significance of the condition on system operation.

2.8 Given a description of the Electrical Distribution System equipment status, **STATE** any corrective actions required to return system operation to a normal condition.

TERMINAL OBJECTIVE

3.0 Given values of Electrical Distribution System operation parameters, **EVALUATE** potential problems that could effect the normal functioning of the system or its components to determine the significance of the existing condition and the actions required to return the system to normal operation.

ENABLING LEARNING OBJECTIVES

3.1 **DESCRIBE** the following major components of the Electrical Distribution System including their functions, principles of operation, basic construction, and power sources:

a. 261-H Substation
b. Motor Control Centers (MCC)
c. Standby Diesel Generators (automatic operation only)
d. Automatic Transfer Switches (ATS)
e. Uninterruptable Power Supply (UPS)
f. Variable Speed Drives (VSD)
g. Safety switch, Manual transfer switch
h. 480 VAC to 120/208 VAC transformer
c. Panel board

3.2 **STATE** the design capacities and operational limitations for the following Electrical Distribution System major components:

a. 261-H Substation
b. Motor Control Centers (MCC)
c. Standby Diesel Generators (automatic operation only)
d. Automatic Transfer Switches (ATS)
e. Uninterruptable Power Supply (UPS)
f. Variable Speed Drives (VSD)
g. Safety switch, Manual transfer switch
h. 480 VAC to 120/208 VAC transformer
c. Panel board

3.3 Given values for key performance indicators, **DETERMINE** if Electrical Distribution System components are functioning as expected.

3.4 **DESCRIBE** the following Electrical Distribution System instrumentation including indicator location (local or Control Room), sensing points, and associated instrument controls:

a. 261-H Substation
c. Motor Control Centers (MCC)
b. Automatic Transfer Switches (ATS)
c. Uninterruptable Power Supply (UPS)
d. Variable Speed Drive (VSD)

3.5 **INTERPRET** the following Electrical Distribution System alarms, including conditions causing alarm actuation and the basis for the alarms.

a. 261-H Substation
c. Motor Control Centers (MCC)
b. Automatic Transfer Switches (ATS)
c. Uninterruptable Power Supply (UPS)

3.6 **EXPLAIN** how the following Electrical Distribution System equipment is controlled in all operating modes or conditions to include control locations (local or Control Room), basic operating principles of control devices, and the effects of each control on the component operation:

a. 261-H Substation Switchgear breakers
b. Motor Control Centers
c. Automatic Transfer Switches
d. Uninterruptable Power Supply
e. VS Drive

f. Safety switch

g. 480 VAC to 120/208 VAC transformer

h. Panel board

TERMINAL OBJECTIVE

4.0 Given necessary procedures or other technical documents and system conditions, **DETERMINE** the operator actions required for normal and offnormal operation of the Electrical Distribution System including problem recognition and resolution.

ENABLING LEARNING OBJECTIVES

4.1 **IDENTIFY** the electrical schematic symbols for the following motor controller components:

a. Contactor or starter electromagnetic coil

b. Selector switches

c. controller START and STOP pushbuttons and lights

d. Main, auxiliary and interlocking contacts

e. Transformers

f. Overload relay and contacts

g. System contacts that interface with controllers

h. MCC plug-in compartments

I. MCC switch and fuses

4.2 Given an electrical schematic, **IDENTIFY** the circuit components and **DETERMINE** their electrical ratings.

4.3 **EXPLAIN** the operation of low voltage release (LVR) and low voltage protection (LVP) circuits

4.4 Given schematic diagram, **ANALYZE** circuit operation and **CLASSIFY** the circuit as either a low voltage protection (LVP circuit or a low voltage release (LVR) circuit.

4.5 Given a controllers schematic diagram, **EXPLAIN** how interlocks from other area devices, panels, or controllers can be arranged in the controller circuit to either permit or prevent the controller from being started.

4.6 **DESCRIBE** ways in which the CIF Electrical Distribution System communicates its status to local operating stations, to control room consoles, and to a high level control system (programmable logic controller or digital control system).

4.7 Given applicable procedures and plant conditions, **DETERMINE** the actions necessary to perform the following Electrical Distribution System operations:

a. Startup
b. Manual Operation of Equipment
c. Shutdown

4.8 **DETERMINE** the effects on the Electrical Distribution System and the integrated plant response when given any of the following:

a. Indications/alarms
b. Malfunctions/failure of components
c. Operator Actions

4.9 **STATE** the responsibilities of the CIF operators as related to the boundaries of the Electrical Distribution System.

SYSTEM OVERVIEW

Safety

Safety Precautions

Electricity that is out of control can be deadly. When a path for electrical current is established, electricity will follow that path. If that path is through the human body, the results can be fatal.

1.01 DESCRIBE the hazards associated with electrical equipment. Include the effects to the human body of receiving an electrical shock at the following current values:

a. 1 milliamp

b. 10 milliamps

c. 50 milliamps

d. 100 milliamps

1.02 DESCRIBE the safety precautions required when working with or near electrical equipment.

Current Effects on the Body

When current flows through the human body, the person is subjected to an electrical shock. Electrical shock can range from a slight tingling sensation to a feeling of a severe blow. The amount of current flow through the body and the duration of the current flow affects the body in different ways.

Have you ever wondered why you can touch both posts of a 12-volt car battery that can produce an electrical current of several hundred amperes, but not feel any sensation of electrical shock? The answer is resistance. Dry skin has a resistance level of 100,000 to 600,000 Ω. Recall from Ohm's law that current flow is calculated by dividing the voltage level by the total resistance. If we divide the battery voltage (12 V) by the lower figure of skin resistance (100,000 Ω) we find that the current flow is .00012 amperes. Although there is current flow, it is of such a small value that it is not felt.

Figure 1, *Typical Body Resistances and Current Flows,* shows typical body resistances and the expected current flow through various paths through the human body when the voltage level is 110 volts.

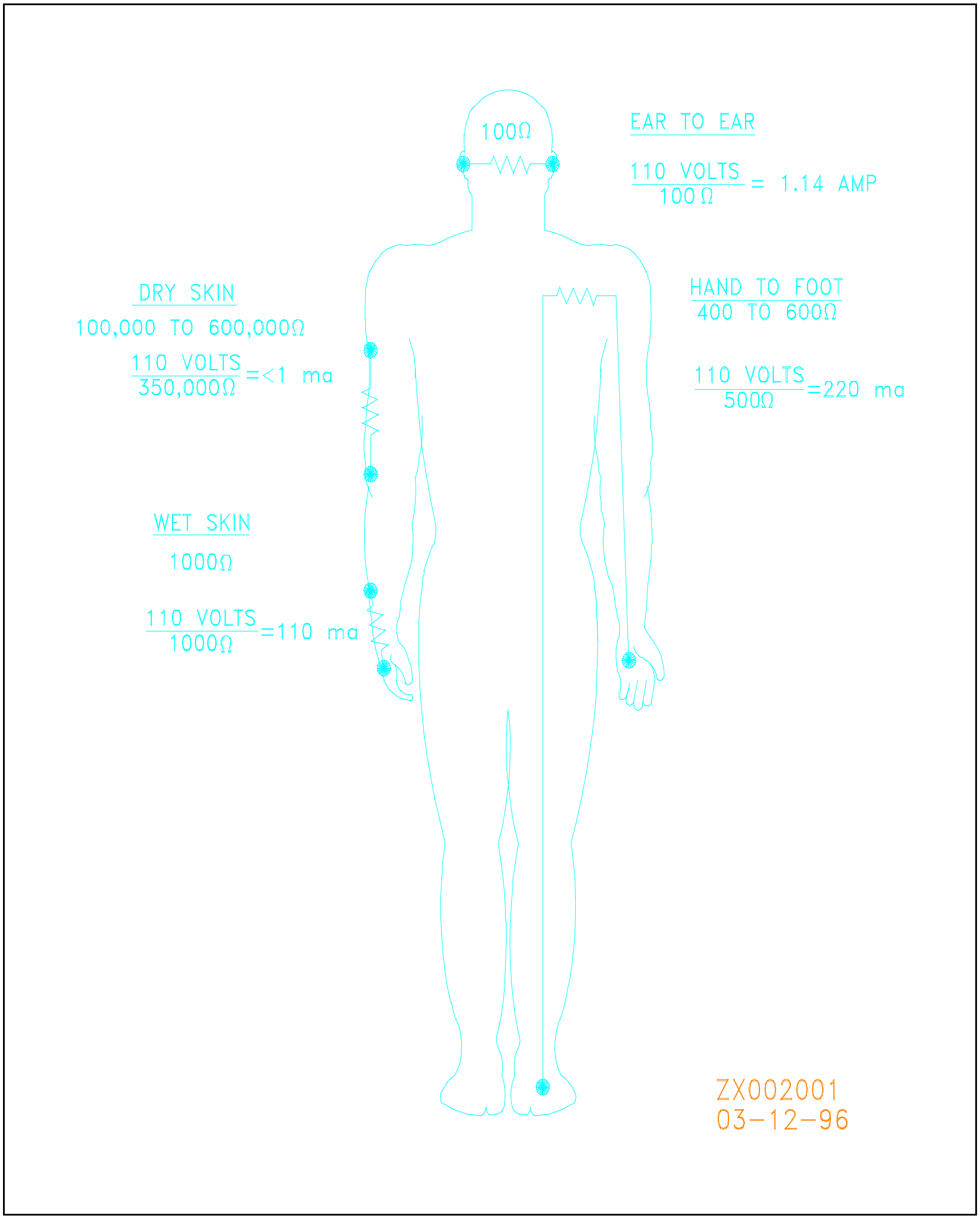


Figure 1 Typical Body Resistances and Current Flows

The following table shows the effects of a 60-Hz, alternating current on the human body:

Current	Effects
1 milliampere or less	No sensation
1 to 3 milliamperes	Some sensation of shock, but not painful - individual can let go at will as muscular control is not lost
3 to 15 milliamperes	Painful shock - sufficient magnitude to prevent about 3 percent of people from letting go at will
15 to 30 milliamperes*	Painful shock - local muscle contractions - sufficient magnitude to cause freezing to the circuit for about 50 percent of the people
30 to 75 milliamperes	Painful shock - severe local muscle contractions - Breathing difficult - can cause unconsciousness or asphyxiation
75 to 200 milliamperes	Possible ventricular fibrillation of the heart**
200 to 300 milliamperes	Certain ventricular fibrillation of the heart**
300 milliamperes and greater	Severe burns and muscle contractions - the contractions can be so severe that the chest muscles clamp around the heart and stop it for the duration of the shock (this prevents ventricular fibrillation)
* There is evidence that skin resistance decreases as the duration of current flow increases (through blistering). If a victim is frozen to a circuit by 15 milliamperes, the decrease in resistance with time might be sufficient to increase the current to 30 milliamperes.	
** Ventricular fibrillation of the heart is a condition in which the heart beats rapidly and out of rhythm. It is usually fatal within a few minutes.	

Table 1 Effects on the Human Body from Electrical Current

As shown by the table, the threshold of pain is between 3 and 15 milliamperes. Currents as low as 30 milliamperes are capable of causing death. General thumb rules for electrical shocks are as follows:

- 1 milliampere - no sensation
- 10 milliamperes - painful sensation of shock
- 50 milliamperes - loss of muscle control
- 100 milliamperes - death if received for more than 1 second

Reducing Electric Shock Hazards

The best way to prevent an electrical shock is to maintain proper distance between current-carrying conductors and any part of your body. However, this is not always possible. During routine operations, operators and technicians are often required to operate or work on electrical equipment. Because of the possibility of an electrical shock, special precautions must be observed:

- Only qualified personnel are permitted to operate, rack in or out, or perform maintenance on electrical equipment.
- Guards should be installed on all equipment to protect personnel from accidental contact with a live conductor, or with rotating parts.
- Grounds should be installed on all electrical equipment casings. Grounds provide a low-resistance path for current to flow to earth. If the equipment is shorted to its casing, the current will flow through the equipment ground and not through personnel touching it.
- Whenever possible, de-energize electrical circuits or components prior to performing work on them. This may not be as simple as it seems. Many control circuits are very complex and may have several sources of power. De-energizing a circuit may involve opening circuit breakers, pulling fuses, opening disconnects, or lifting electrical leads. Electrical schematics must be thoroughly researched by qualified personnel to identify all sources of power.
- All electrical equipment must be considered energized until proven de-energized by qualified personnel. This should be accomplished by checking the circuits and conductors for voltage prior to starting any work.
- Lock-out procedures should be followed precisely.
- Never reset a circuit breaker trip, or a motor control center (or separately mounted) starter overload "RESET" button, unless the cause of the trip or overload is understood and corrected. (The Conduct of Operations Manual allows one reset of a 115 V-ac breaker after verifying no apparent deficiency.)

The above are summary points from existing site-wide practices. For details, refer to Manual 18Q, *Safe Electrical Practices and Procedures(U)*, using Shrine under On-Line Documents and Manual Access, SRS On-Line Manual System.

Summary

- Because electricity can be dangerous if handled improperly, proper procedures and practices must be observed. Refer to Manual Number 18Q for site-wide practices.

INTRODUCTION AND SYSTEM OVERVIEW

This section provides an overview of the CIF Electrical Distribution System and provides definitions for common electrical terms that are used in later sections.

2.01 DEFINE the following electrical terms:

a. Area Substation
b. Transformer
c. Distribution Substation
d. Motor Control Center (MCC)
e. Automatic Transfer Switch (ATS)
f. Contactor
g. Motor Starter
h. Panel board
1. Circuit Breaker
j. MCC Switch and Fuses
k. Disconnect switch, safety switch, manual transfer switch
l. Tie-breaker, main breaker, feeder breaker, switch gear
m. Normal power/multiple sources
n. Alternate power
o. Standby Diesel Generator Power
p. Vital/Essential load
q. Electrical fault

The CIF Electrical Distribution System comprises all the electrical hardware that is located between the site-generated electrical power or commercially purchased electrical power and the CIF loads.

The CIF Electrical Distribution System provides the components to connect and disconnect loads, a means to electrically protect loads and cables, and the necessary instrumentation to monitor itself.

Because the electrical equipment interfaces with almost all mechanical systems, it provides a convenient vehicle for coordinating the functions of different mechanical systems. Because the electrical system is central to many systems, it is vital that at least part of the electrical system be operable at all times. This is accomplished by providing loads with multiple sources of normal power, and by providing vital/essential loads with a source of standby diesel generator power. Finally, loads which should never be without power, even instantaneously, are powered by a source of "uninterruptable" power that uses batteries for reserve power. This uninterruptable power system (UPS) feeds the CIF Distributed Control System (DCS) and the majority of the DCS instruments.

Common Electrical Terms

There are numerous types of devices that can be found in a typical Electrical Distribution System. Each of these devices perform a specific function. In order to obtain an understanding of how the CIF Electrical Distribution System functions, some of these terms must first be understood. The following is a list of definitions for the common devices found in the CIF Electrical Distribution System:

a) **Area substation** - receives power from the Site Electrical Distribution System for use in the CIF. A substation contains a switch, a transformer and circuit breakers.

b) **Transformer** - raises or lowers the voltage of an AC power source. Typically, transformers are used to reduce the high voltage of the Site Electrical Distribution System to usable levels for CIF equipment.

c) **Distribution Substation** - a load center which consists of a transformer, with its high voltage side disconnect switch, low voltage side circuit breakers, and buswork. A distribution substation will receive high-voltage power, transform the power to lower values (typically 480 VAC), and distribute the power to process loads.

d) **Motor Control Center (MCC)** - receives 480 VAC power for process equipment and distributes this power to small 480 VAC loads. MCCs also contain metering equipment, equipment control devices, and protective relays.

e) **Automatic Transfer Switch (ATS)** - used to automatically provide backup or emergency power to an essential piece of equipment. When normal power is lost, the ATS will automatically transfer to supply power to the load from a standby power source.

f) **Contactor** - an electro-mechanical device that controls power to a piece of equipment. Control switches use a contactor to turn equipment on and off. These devices are sometimes referred to as controllers and are typically used to control lights or heat trace equipment.

g) **Motor Controllers** (or Starters) - electrical components that include contactors, overload relays, and other miscellaneous control devices necessary to operate and protect the load motor. Motor controllers are specifically designed for controlling power to a motor. Motor controllers contain protective devices to protect the motor from damage due to overloading.

h) **Panel Boards** - small distribution panels which contain numerous molded-case breakers. The breakers provide power to small loads at either 120 VAC or 208 VAC.

i) **Circuit breakers** (breakers) - mechanical devices used to control power to a load. Breakers typically contain overcurrent devices to automatically isolate the load from the power source when a high-current condition occurs.

j) **Disconnect switches/safety switches**, **manual transfer switch** - similar to breakers in function; however, these switches may or may not contain fuses to protect downstream loads. Disconnect switches are typically used to isolate substation transformers from their source of power. Safety switches are used in circuits under 600 volts and are used as isolating devices for their loads. Some switches have the ability to source power from two different sources. These are manual transfer switches.

k) **Tie-breaker** - used to tie together two electrical bus systems.

l) **Main breaker** - used to connect bus bars of switchgear assemblies to the output of transformers.

m) **Feeder breaker** - receive power from switchgear bus bar and direct the power to downstream loads.

n) **Switchgear** - an assembly of circuit breakers that are electrically connected to a system of electrical buses (solid copper conductor bars).

o) **Normal power** - power that is received from the normal source; in the case of CIF, power received from the Site 115 kV Power Distribution System.

p) **Multiple sources** - parts of the distribution system which can furnish downstream components with at least two sources of (normal) power. For example the 115 kV Site Distribution System can supply the H-Area main substation with five different sources of power: Three sources from South Carolina Electric and Gas, one source from Georgia Power, and one source from SRS's on-site generators.

q) **Standby diesel generator power** - furnishes power to all CIF vital/essential loads by means of diesel generators located in the CIF.

r) **Vital/essential loads** - loads that ensure that the facility can function safely whether the facility is in an operational mode or shutdown mode.

s) **Electrical Fault** - electrical problems such as component overloads, short circuits and open circuits that prevent electrical equipment from functioning properly.

Summary

- The terms and definitions provided in this section are used throughout the subsequent text.

CIF ELECTRICAL DISTRIBUTION SYSTEM PURPOSE AND FLOWPATHS

This section provides an overview of the CIF Electrical Distribution System.

2.02	**STATE the purposes and features of the CIF Area Electrical Distribution System.**
2.03	**With the aid of a site Electrical Distribution one-line diagram, IDENTIFY the source of power and system voltage supplied to the H-Area.**
2.04	**IDENTIFY all the sources of power that supply the site distribution system and IDENTIFY the voltage levels of the sources.**
2.05	**Using an electrical schematic drawing of the H-Area (251-H) main substation, STATE the source of electrical power and system voltage that supports the CIF Substation at building 261-H.**
2.06	**NAME all the major components in the correct sequence that they would be encountered as power flows from the 13.8 kV CIF source, or from the standby diesel generators, all the way to the panel boards.**
2.07	**Given a single-line diagram of the Electrical Distribution System, IDENTIFY normal and standby power supplies for motor control centers and panel boards, and IDENTIFY the name of the MCC electrical component that is located in MCC compartments.**
2.08	**IDENTIFY all the power supplies that feed to, or are an integral part of the uninterruptable power supply (UPS).**

Introduction

The CIF contains a variety of equipment necessary for the processes. This equipment requires a reliable source of power at various voltages for proper operation. In addition, personnel and equipment safety, system flexibility, and standby power to vital loads are all considerations in providing this power.

CIF Electrical Distribution System Purpose

The purpose of the CIF Electrical Distribution System is to provide the CIF with the required electrical power to operate process equipment. The system accomplishes this purpose through the following functions and features:

a) Reduces the voltage of the power received to usable levels and distributes this power to the electrical loads.
b) Provides protective equipment to minimize personnel and equipment hazards.
c) Provides backup power to vital/essential facility loads if normal power is lost.
d) Supports facility reliability by providing multiple power sources to major areas.
e) Provides an uninterruptable power supply to feed those loads that cannot be without power even for an instant.

The CIF Electrical Distribution System uses a network of transformers, breakers, disconnects, and motor control centers to provide these features. Backup power is provided through standby diesel generators.

Design Basis (Features)

In designing the CIF Electrical Distribution System, sound engineering bases were followed. In addition to those key features listed above, some important design features are provided.

- Safety - In order to design a safe system, the following features were incorporated into the electrical system:

  a) All operator control devices are at 120 VAC or lower.
  b) Breaker interrupting capacities always exceed the potential fault capabilities by a wide margin (i.e., the breakers will always clear a fault regardless of how serious the fault may be).
  c) All major components have dead front construction (no active voltage on the front panels) and are grounded securely. This ensures that the parts of equipment that operators may come in contact with will not be electrically charged.
  d) Inappropriate operation of electrical equipment is prevented by mechanical interlocking devices designed to prevent operation of one device.
  e) All electrical equipment is arranged for lock-out devices. In many cases, equipment can be withdrawn completely from a compartment, thereby eliminating any possibility of inadvertent energizing.
  f) All rotating devices (motors and generators) are equipped with rotating part guards.
  g) All remotely-mounted electrical components are equipped with nearby safety switches,

such as power switches in series with the component, or "B" type control switches. The "B" type switches are connected directly into the circuit of motor controllers and are used to prevent the motor from being started. The safety switches are designed to provide a safe local disconnect source for the respective loads.

- High voltage is handled by SUD (Site Utilities Department).
- Coordination - Major component protective devices were designed with the widest tripping ranges possible between two devices to ensure both a safe system and selective tripping, which ensures minimum system degradation due to an electrical fault.
- Multiple power sources - Both the site 115-kV Power Distribution System and the 13.8-kV Area Distribution System can provide downstream loads with at least two sources of power.
- Essential loads are backed up with standby diesel generator power. The standby generators are arranged to provide standby source of power within 30 seconds of a loss of normal power. Each essential load, whether in an area of multiple electrical components or in a remote area, has a source of standby diesel generator power. UPS bridges the gap between normal power loss and startup of SDG for critical loads.
- Some large essential loads are equipped with a source of standby power, but are purposely arranged to be started manually on standby generators. This permits Operations personnel to decide the most appropriate time to re-energize these large loads.
- Component Sizing - All components have been generously sized, which permits the devices to be operated far below their design capacity. Cabling between components is also sized conservatively.
- Voltage Transformations - Because H Area is spread over a wide area, electrical power is delivered to convenient locations within the area at 13.8 kV. This power is stepped down to the process voltage of 480 VAC.
- Some equipment requires a lower voltage. Therefore, power is directed as close to the process loads as possible at 480 VAC, and then is transformed to 120/208 VAC.
- Alarm panels are located at key operating locations. Many of the alarm panels are equipped with instrumentation which is designed to inform Operations regarding the status of the electrical system.

Site 115 kV Power Distribution System Flowpath

The Site 115 kV Power Distribution System receives off-site power from three separate power lines (See Figure 2, *SRS 115kV Distribution*). Two 115-kV lines (SCE&G 1 and SCE&G 2) enter the site and connect to the system at buildings 504-2G and 504-1G. A 230-kV line, SCE&G 3, enters the site and connects to a 230/115-kV substation where the power is transformed to 115 kV. The 115-kV power from this substation then connects to the Site 115 kV Power Distribution System at Building 504-3G

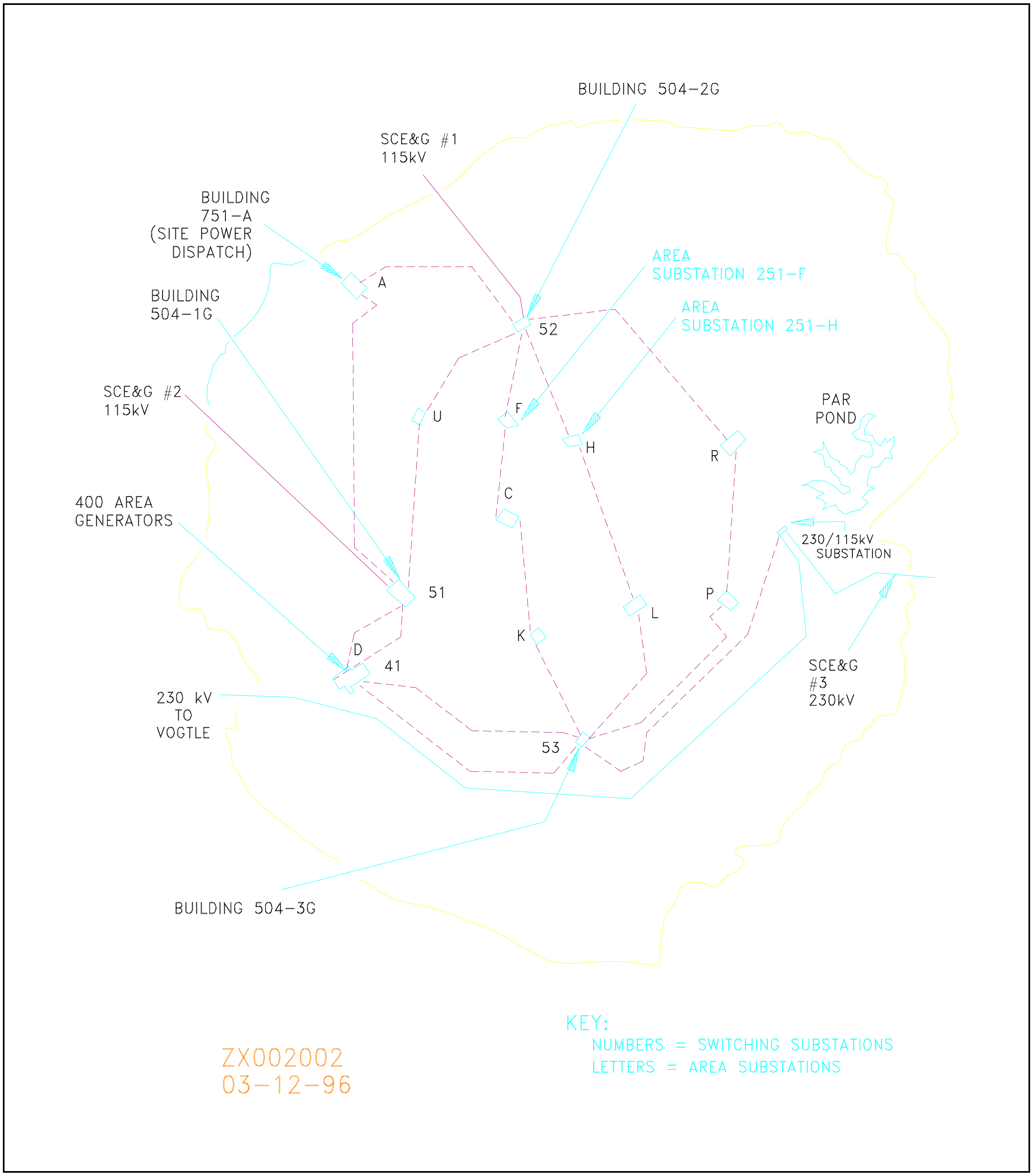


Figure 2 SRS 115 kV Distribution

Seven generators, located in the 400 Area, provide an additional power supply to the Site 115 kV Power Distribution System. The generators connect to the Site 115 kV Power Distribution System at switching substation 41, also located in the 400 Area.

The power from the site generators and from the commercial supply lines are interconnected using switching substations, controlled by the Power Operations Department. These switching substations are used by the power dispatcher to control the distribution of the site power sources.

Power to H Area is received from two power supply lines: One line originating from switching substation 52, and the other line originating from switching substation 53.

H-Area 13.8 kV Distribution System Flowpath

The H-Area 13.8 kV Distribution System receives power from switching substations 52 and 53 into area substation 22 in Area 251-H (see Figure 3, *Area Substation 22 in 251-H Area).* Within the area substation, 115-kV power from each line is supplied through a 600-amp disconnect to 115 kV/13.8 kV transformers. The secondary of each transformer then supplies power to a 13.8 kV bus via a 13.8 kV supply breaker.

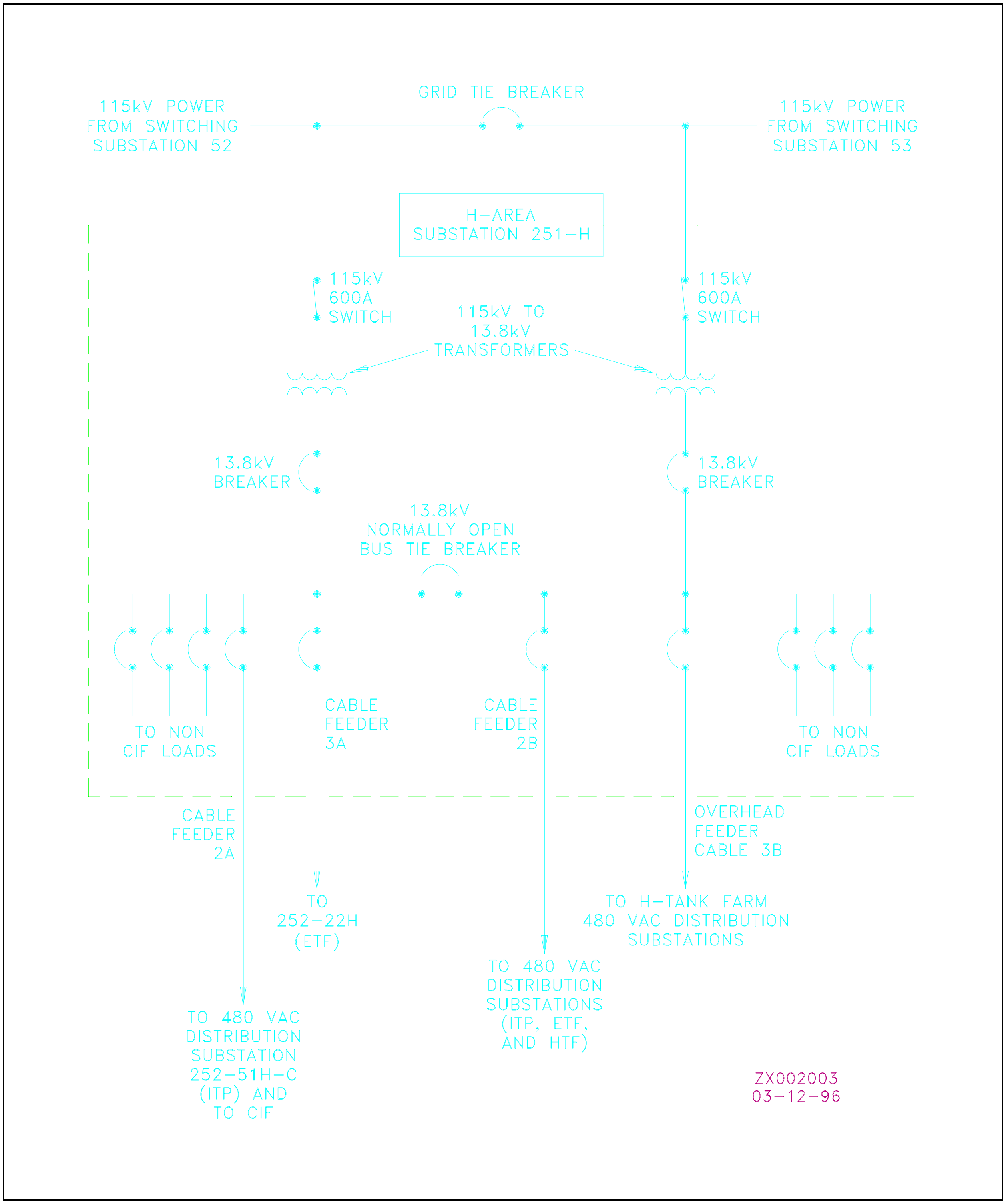


Figure 3 Area Substation 22 in 251-H Area

There are two 13.8 kV buses in area substation 22. Each bus contains load breakers that distribute power to CIF and other area 13.8 kV loads. For system flexibility, a 13.8 kV bus tie breaker is provided to allow one 13.8 kV bus to supply power to the other in the event that a power supply line was not available. This 13.8 kV bus tie breaker is normally open.

Power to the CIF Electrical Distribution System is provided from area substation 22 through three cable feeders 2A.

CIF System Flowpath

(See Figure 4, *CIF Power Distribution Block Diagram.)* The CIF Electrical System begins at the 1500 kVA substation. The substation consists of a 13.8kV primary disconnect switch, 1500KVA transformer, and 480V switchgear enclosed in an outdoor, weatherproof, walk-in enclosure. The primary disconnect switch is a 600 amp non-fused, load-break disconnect switch.

The substation receives a 13.8 kV power feeder from the H-Area 2A feeder. The substation transformer converts the 13.8 kV supply to 480V and distributes the power to the eight MCCs via the substation switchgear breakers. The MCCs distribute power to the 480V motor loads, 50kVA Uninterruptable Power Supply (UPS), the heat trace distribution panel transformers, lighting distribution panel transformers, and miscellaneous power panel transformers. Two of the MCCs contain standby loads which must power up within 15 minutes after a loss of normal power to ensure a safe incinerator shutdown. Each of the standby MCCs has a diesel generator for backup power during a loss of normal power incident.

The remaining Electrical System provides power for 120 V needs. These loads include small fractional horsepower motors, heat trace, lighting, and receptacles.

(See Figure 5, *CIF Electrical Distribution System One-Line.*)

The Electrical System is comprised of six subsystems. The following list is the six subsystems with CIF acronyms:

1. ELNA 13.8Kv Substation
2. ELNH 480V Motor Control Centers (MCCs) and Panels
3. EEP Emergency Electrical Power
4. UPS Uninterruptable Power Supply
5. HTTR Heat Tracing
6. ELLV 120Vac Power Panel

CIF SINGLE LINE DIAGRAM

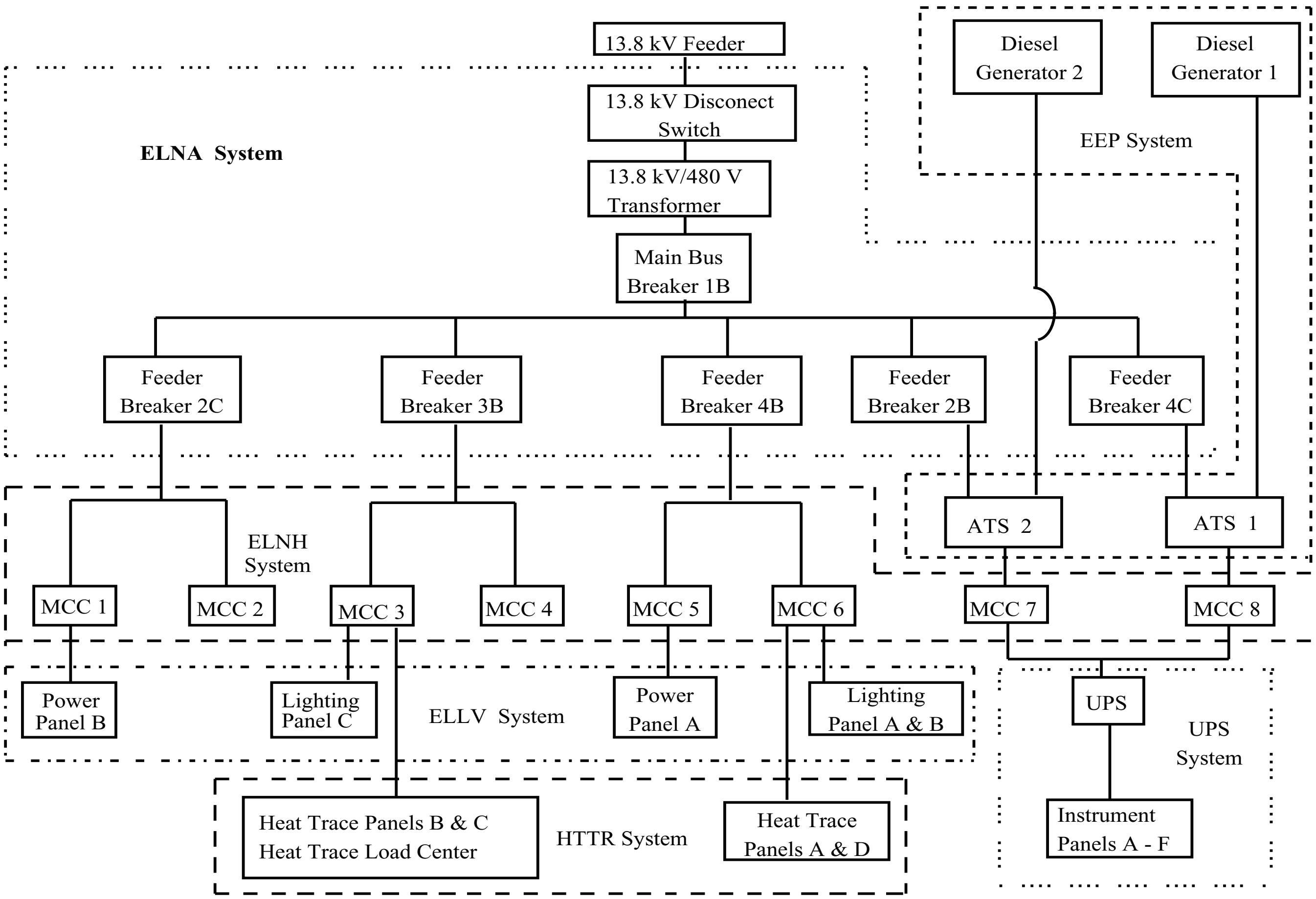


Figure 4 CIF Electrical Distribution System One-Line Diagram

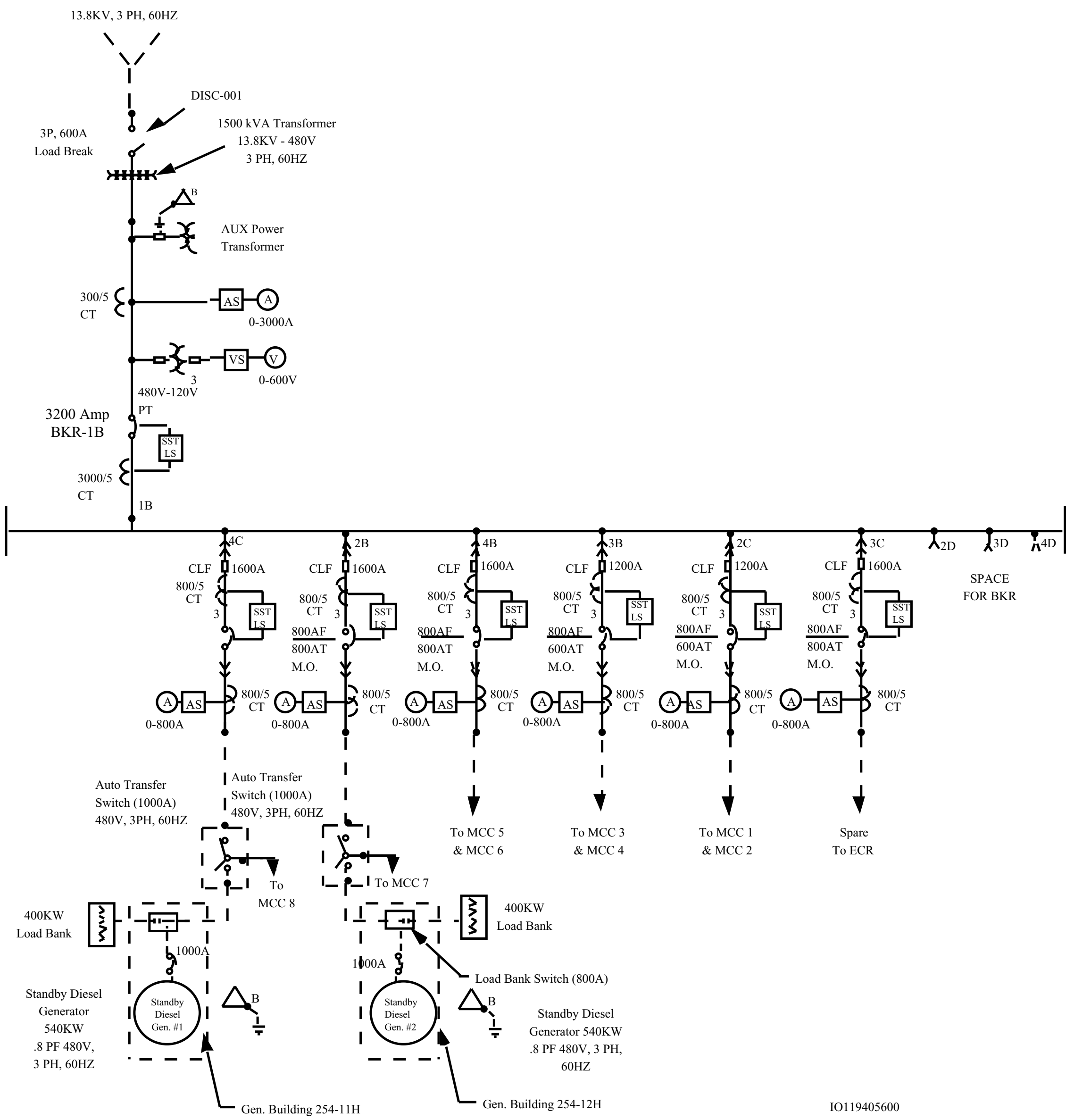


Figure 5 CIF Electrical Distribution System One-Line Diagram

UPS Flowpath

The flowpath to the UPS is important to understand how the UPS functions (Refer to Figure 6.)

Figure 5 shows how power is directed to the MCCs. The UPS has several sources of power, as noted on Figure 6. A list of all the sources of power to the UPS follows:

a. **Primary normal**: MCC-7 compartment 4-H supplies the UPS normally.

b. **Normal back-up**: MCC-7 compartment 4H supplies the UPS with a source of standby diesel generator power from SDG 002 via ATS 002 if normal power is lost.

c. **By-pass normal**: MCC-8 compartment 6J supplies the UPS with a source of power via a 480 to 120/208 VAC transformer. This power only is used if the primary normal power is unavailable, and if the normal back-up power from SDG-002 is unavailable.

d. **By-pass back-up**: MCC-8 compartment 6J supplies the UPS with a source of backup power from SDG 001 via a 480 to 120/208 VAC transformer. This by-pass back-up power only is used if the primary normal, the primary back-up, and the by-pass normal power all are unavailable.

e. **Battery power**: Battery power is always connected to the UPS and automatically assumes the load (through a DC to AC Inverter) if the power coming from MCC-7 compartment 4H is unavailable (either primary normal or back-up).

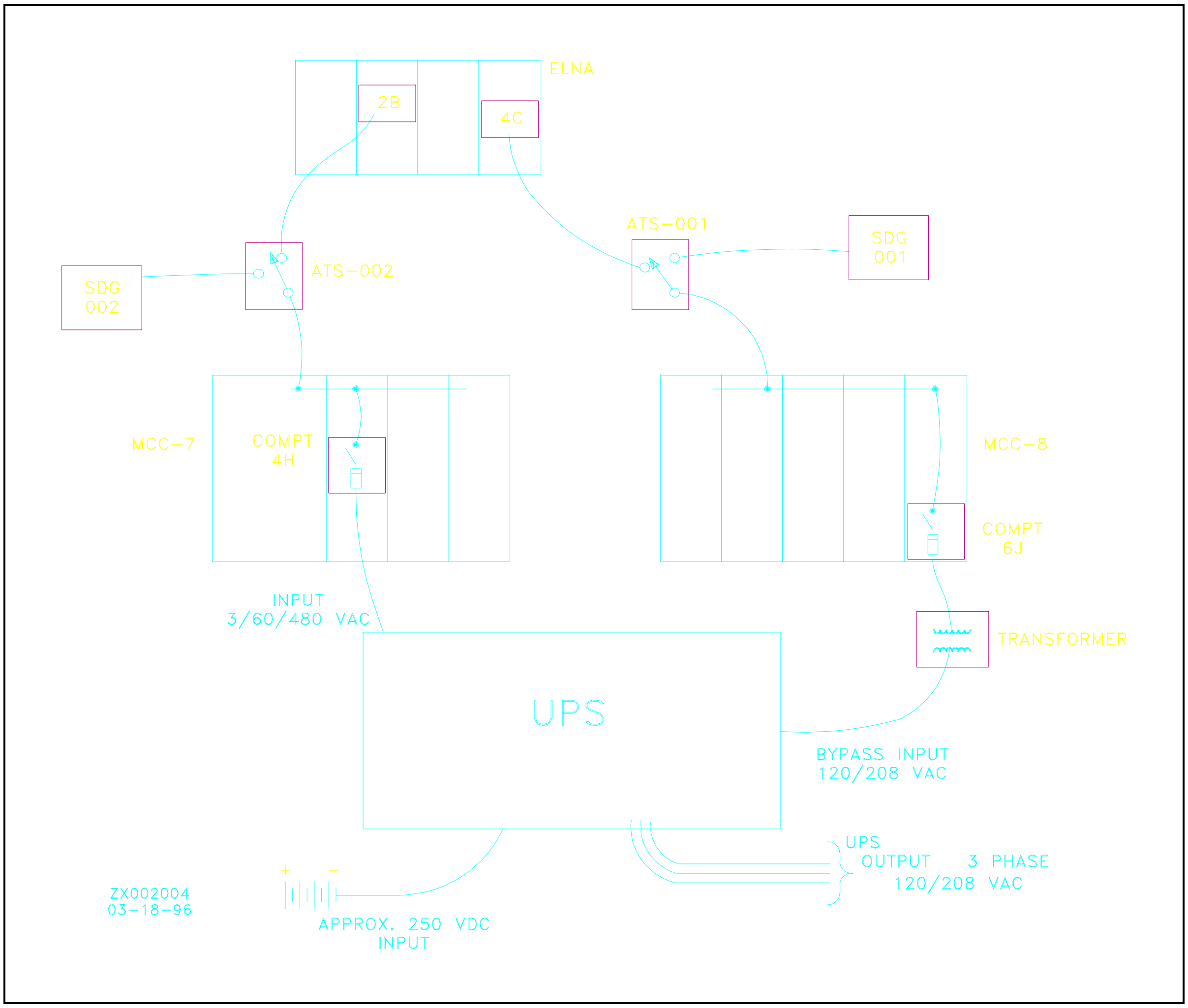


Figure 6 UPS Flowpath

Summary

- The purpose of the CIF Electrical Distribution System is to receive power from site sources, transform the voltage to levels required by the process, provide multiple sources of power (alternate or standby), and to accomplish this in a safe manner. All electrical components used in the Electrical Distribution System were applied conservatively in order to provide maximum personnel safety and maximum system reliability.

- Functions of the Electrical Distribution System can be summarized as follows:

  a) Reduces voltage and distributes power
  b) System is self-protecting and designed to protect personnel
  c) Uses standby diesel generators as backup power
  d) Utilizes multiple sources of commercial power
  e) Provides a source of uninterruptable power to those loads that should never be without power, even instantaneously

- Features of the Electrical Distribution System can be summarized as follows:

  a) Designed with personnel safety in mind
  b) Faults are contained to as small an area as possible
  c) Multiple sources provide options if the normal source is faulty
  d) Diesel generators are on-line in 30 seconds or less
  e) Controls arranged so that all motors do not start at one time after a loss and return of power
  f) Components applied far below capacity
  g) Power transmitted at high voltages to reduce losses
  h) System is self-monitoring

.

MAJOR COMPONENTS

This section describes the major components of the Electrical Distribution System. A general understanding of the function of each component is necessary to determine how power flows through the system to the loads.

2.09 IDENTIFY the functional areas of CIF that are fed by each motor control center.

3.01 DESCRIBE how the following components function to support operation of the CIF-Area Electrical Distribution System:

- **a. 13.8 kV Area Substations**
- **b. 480 VAC Distribution Substations**
- **c. Motor Control Centers**
- **d. Variable Speed Drives**
- **e. Standby Diesel Generators**
- **f. Automatic Transfer Switches**

3.02 DESCRIBE how the following components function to support operation of the CIF Area Electrical Distribution System:

- **a. Panel boards**
- **b. 480 VAC to 120/208 VAC transformers**
- **c. Uninterruptable power supplies**
- **d. Safety Switches**
- **e. Control devices**
- **f. Manual transfer switches**

13.8kV Supply

(See Figure 5, *CIF Electrical Distribution System One-Line Diagram.*). The 13.8kV supply comes in off the line feeder located east of the CIF Building. The 13.8kV power supply for overhead pole line run along the north side of the facility. This line is tapped at the H-Area feeder 2A near existing pole 219. A 600-amp isolation disconnect is provided near the tap point to shut off power while performing maintenance on the line. The overhead line terminates at a 600-amp, pole-mounted fused isolation disconnect. An underground feeder runs from the isolation switch to the primary disconnect at the CIF substation.

Unit Substation

The unit substation is located due east of the truck unloading bays. The substation consists of a 13.8kV primary disconnect switch, 1500KVA transformer, and the 480V switchgear.

The primary switch is a 600-amp, non-fused, load-break disconnect switch with a visible blade and provisions for padlocking. The switch allows the interruption of power at the substation for maintenance or testing of the transformer and switchgear.

The transformer is a 1500KVA oil-immersed type with a three-phase 13.8kV delta primary and a 480V delta with B phase grounded. The low side of the transformer has the B phase grounded to protect the system during phase-to-ground faults.

The transformer includes manually adjustable no-load taps to adjust output voltage in case of long-term fluctuations in primary distribution voltage.

The switchgear includes a main 3200-amp draw-out power circuit breaker and six 800-amp feeder circuit breakers (five (5) active and one (1) spare). The five (5) active breakers feed the eight (8) MCCs. Two (2) MCCs are connected to each breaker feeder with the exception of the emergency MCCs (7 and 8) which are fed from single dedicated breakers. There is also space provided for an additional three (3) breakers.

All of the circuit breakers are equipped with solid-state trip units with long-and short-time trip settings. The feeder breakers are also provided with current-limiting fuses to protect the circuit breakers and the load side equipment during extremely high current fault.

Switchgear breakers are typically identified by the compartment position of the breaker in the assembly. Switchgear assemblies are identified by the structure number (column number, usually 1, 2, 3, etc.), and by the compartment letter in each column (usually identified as A, B, C, and D, with A at the top and D at the bottom). The location of a 480-VAC distribution substation breaker feeding a particular motor control center is identified by the substation and compartment position. For example, substation 261-H compartment 4C is the feeder breaker for MCC 8.

Switchgear breakers are rated by the following:

1. Voltage - the designed maximum voltage of the breaker
2. Frame continuous current - the designed maximum continuous current capacity of the breaker
3. Type of actuation - either manually operated or electrically operated
4. Current interrupting capacity-the maximum current the breaker can interrupt in the event of a high-current condition

Substation switchgear breakers are standard frame sizes, ranging from the smallest of 600 continuous amperes to the largest of 4000 continuous amperes. To accommodate loads smaller than the standard frame rating, trip units are installed to tailor the breaker to the needs of the load. For example, a 375-ampere load could be supplied from a 600-ampere frame breaker with a trip unit of 400 amperes.

Trip units can be arranged to trip substation switchgear breakers for long-term sustained overloads or for short-term overloads caused by short circuits. By selecting the proper trip unit and trip settings, downstream breakers or fuses will isolate an overload or short circuit prior to the switchgear breaker opening on overcurrent. Selective tripping is the coordination of overcurrent trip settings so that the breaker or fuse nearest the fault opens to clear the fault before the substation breaker opens. Refer to the *System Interrelationships and Operation* section of this study guide for further information regarding coordination of protective devices within major components of the Electrical Distribution System.

Interrupting capacity of a switchgear breaker is the maximum current that can be safely interrupted by the breaker. Interrupting capacity is important only in unusual circumstances, such as a short circuit. If a short circuit occurs at a point close to a distribution substation, there is very little resistance in the circuit to limit the current. A short circuit on the CIF area distribution substation could cause very high current; therefore, switchgear breakers are supplied with current-limiting fuses.

On Figure 5, the label for each breaker identifies its frame size and current trip setting. The letters “AF” following the rating refer to the frame size (for example, 800 AF); the letters “AT” following the rating refers to the trip setting (for example, 600AT). Current limiting fuses are shown as “CLF”.

ELNH Subsystem - 480 V Motor Control Centers (MCCs) and Panels

The eight (8) CIF MCCs are located in the Electrical Equipment Room (EER), which is at the southeastern corner of Building 261-H. The ELNH subsystems basic function is to distribute power to the CIF 480-VAC load. The system is comprised of eight (8) 480V MCCs. The MCCs include motor starters, contactors and feeder switches to provide 480V power for various facility loads. MCCs are furnished with combination fuse-disconnect starters with control transformers and motor overloads. Each MCC is provided with a main incoming fused disconnect switch. Six (6) of the MCCs only have a power feed from the CIF Substation. MCCs 7 and 8 have an automatic transfer switch (ATS) on the line side. This allows them to receive alternate 480V power from the diesel generators during power interruptions.

The MCCs are placed with two MCCs back to back and an aisle space, then two more MCCs back to back. Each MCC has a small glass window to view the MCC main disconnect switch position. Each MCC cubicle has a disconnect switch with a position indicator. The disconnect switch is lockable to prevent inadvertent operation during outages or for maintenance.

Motor Control Centers (MCCs)

MCCs are a key component in the CIF Electrical Distribution System. MCCs are a convenient way of grouping together different types of electrical components, tied together by bus bars. (Refer to Figure 7 and 8). MCCs typically contain some, or all, of the following:

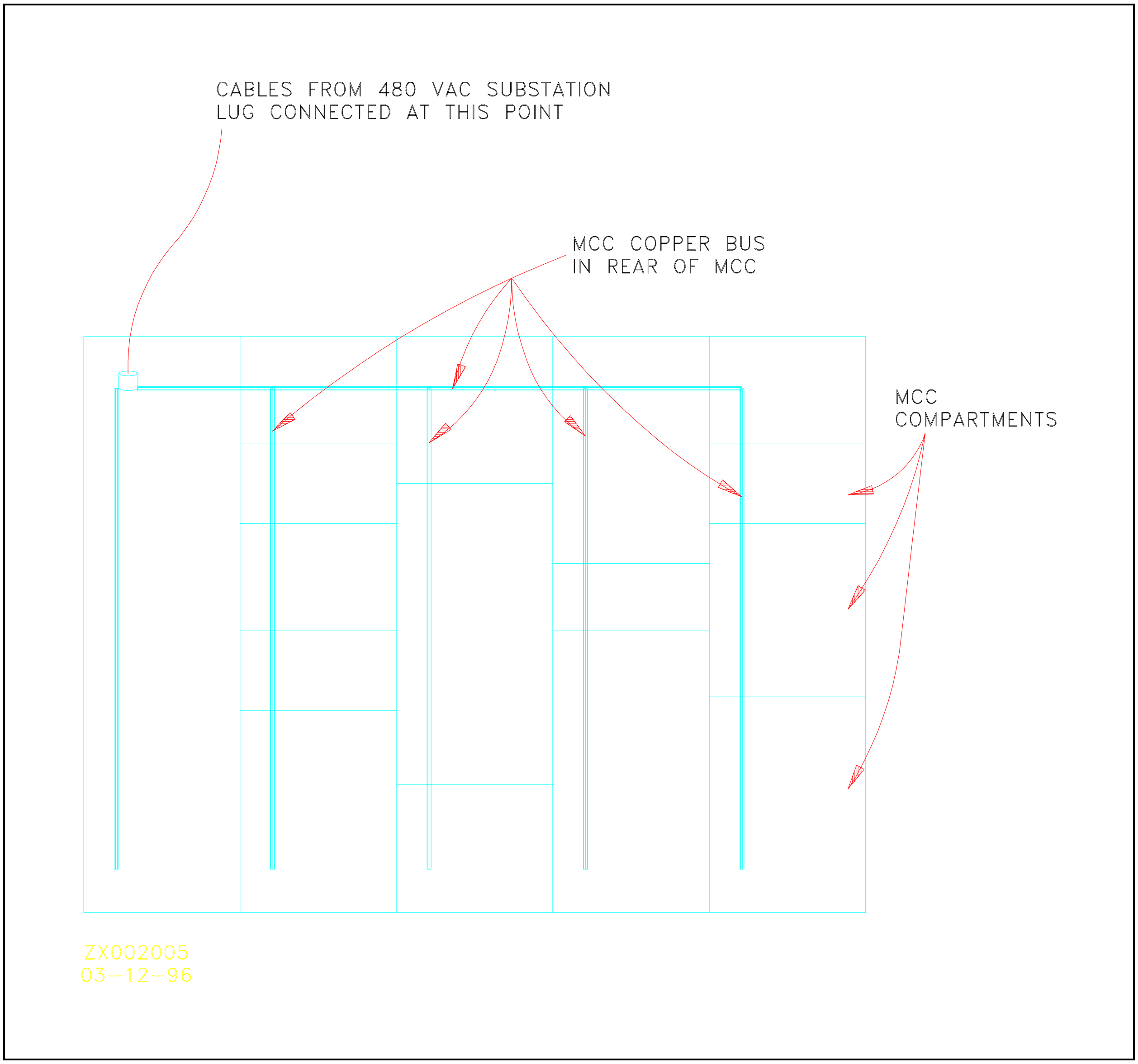


Figure 7 Typical MCC Bus

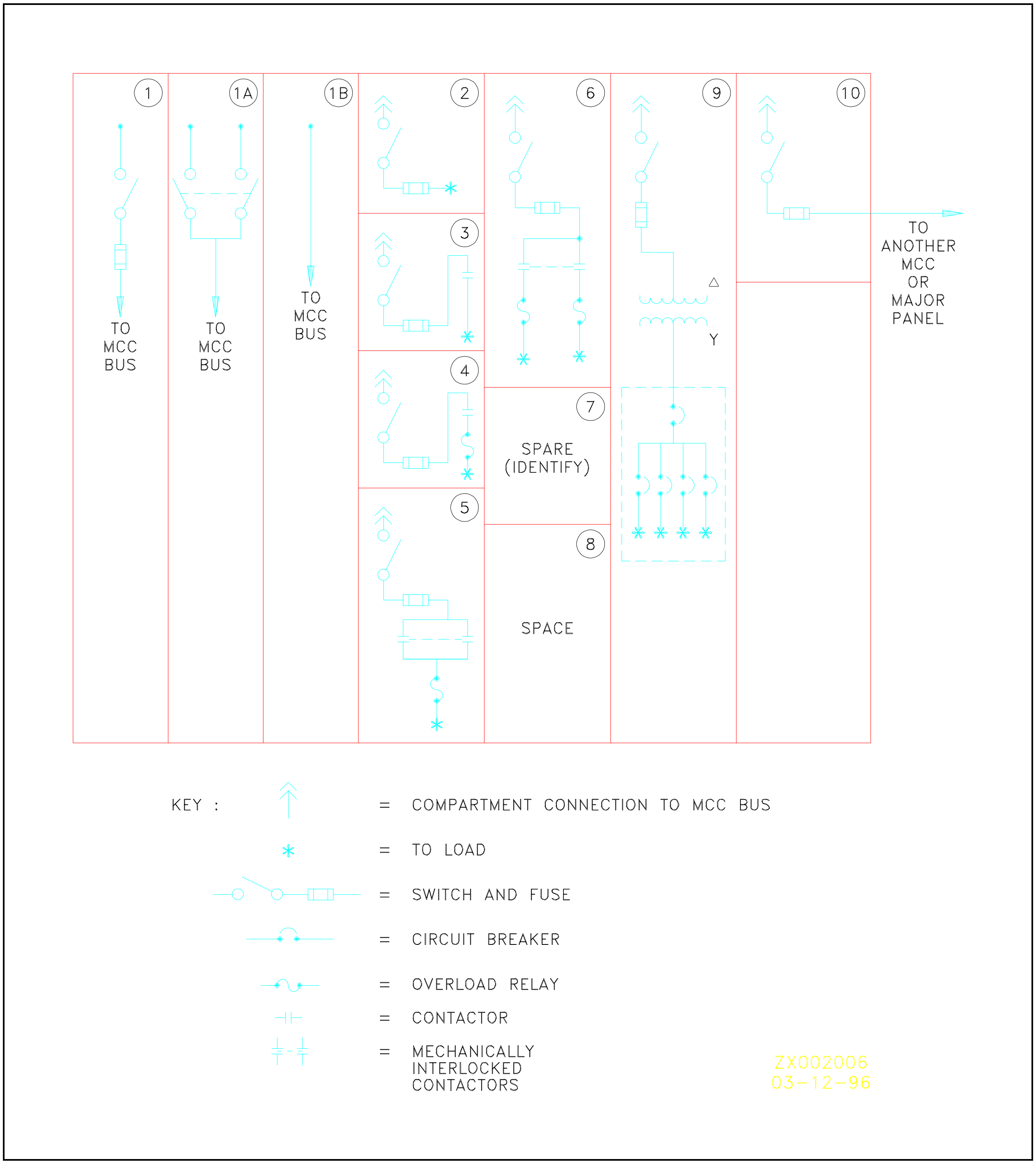


Figure 8 Typical MCC Components

(1) **Non-reversing (NR) combination starters** are used for starting and controlling single-speed induction motors. Combination starters include a disconnect means (switch), a contactor, an overload relay to protect the motor, a control power transformer to provide a control voltage lower than the motor line voltage, provisions for interlocking controls as required, and operators' devices (e.g., pushbuttons, lights). The NR combination starters are sized according to the horsepower of the motor being driven. NR combination starters typically drive equipment such as fans, pumps, and blowers. Refer to item 4 on Figure 8.

(2) **Reversing (R) combination starters** are used for starting and controlling motors that must be reversed. Hardware is similar to hardware for NR starters except that two contactors are required, one for each direction. Reversing combination starters typically drive equipment such as the box lift that must be reversed. Refer to item 5 on Figure 8.

(3) **Fused feeder switches (line switches and fuses)** for feeding power at 480 VAC to hardware such as small power transformers, heaters, air conditioners, sampling systems, hoists, and self-contained crane controls and air compressors. (Refer to item 2 on Figure 8).

- In some cases, large MCC feeder switches supply power to other major pieces of equipment, such as air compressor controllers. (Refer to item 10 on Figure 8).

(4) **Contactors** are used for starting and stopping loads that do not require overload protection. Hardware is similar to the NR starter except that the overload relay is omitted. Contactors typically feed loads such as heaters and outdoor lighting where it is desirable to turn the loads on or off from a remote location. (Typically, Panel boards that energize lights must be turned on or off at the panel board breaker. If a contactor were used instead of a Panel board breaker, the contactor could be energized from a remote location by a pushbutton, or the contactor could be energized by a light sensing switch. Using a contactor is particularly useful for automating the energizing of outdoor lights.) (Refer to item 3 on Figure 8).

(5) **Two-speed, non-reversing starters** similar to item 1 above, except that they are used to drive special motors that can run at two speeds. For example, they are used on process water pumps. Two-speed starters have two contactors, and two overload relays. (Refer to item 6 on Figure 8).

Miscellaneous electrical components:

- Reset button. Items 1, 2, and 5 above each have overload relays which are designed to de-energize their loads if the loads become excessive for the motor that is being protected by the overload relay. A reset button on the MCC compartment door resets the overload relay. (Overloads are reset only after the cause of the overload has been determined.)

- Operator's devices such as pushbuttons, selector switches, indicating lights. Items 1, 2, 4, and 5 above must be energized by operator’s devices, which may be located at operator’s consoles or as part of the DCS system.

- Timing relays and auxiliary relays. Some non-reversing (NR) combination starters have extra relays to provide special functions. Timers and auxiliary relays are used to coordinate starting or stopping to satisfy interlocks required by the logic circuitry of the motors. The Tank Farm Cam Vacuum blower motors use timing relays for sequencing.

Motor control centers are equipped with main incoming disconnect switches and fuses to isolate the MCC from the Electrical Distribution System.

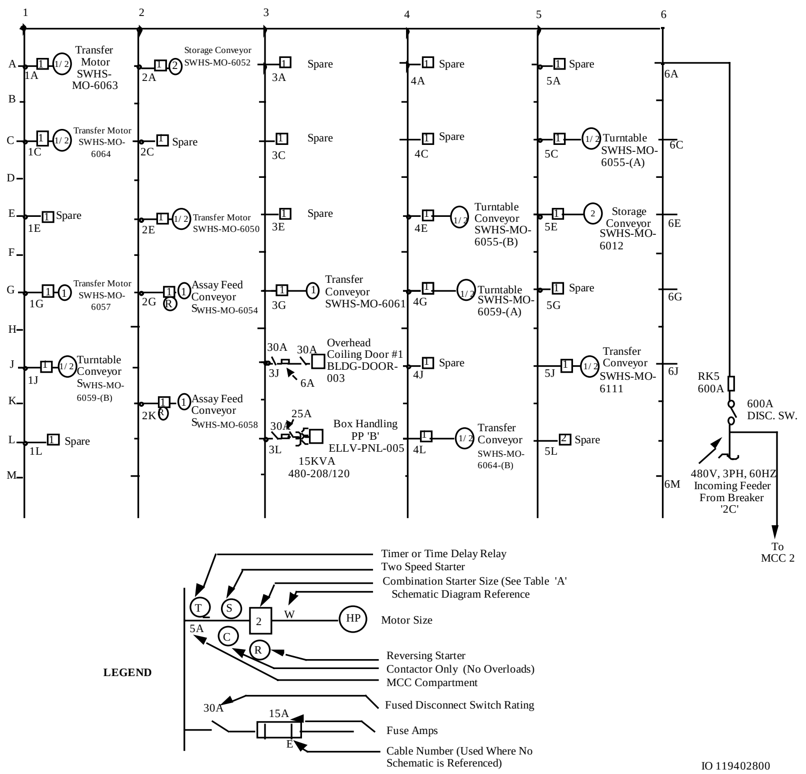


Figure 9 MCC 1

MCC 1 and MCC 2 primarily feed the Box Handling area. Plant air compressor and the breathing air compressor #1 are fed from MCC 2. MCC 1 is fed by CIF substation breaker H-261-ELNA-BKR-2C. Two cables per phase are run from breaker H-261-ELNA-BKR-2C to the line side of MCC 1, 600A main disconnect switch. Two other cables are phase-jumpered to MCC 2 from the line side of MCC 1 main disconnect switch.

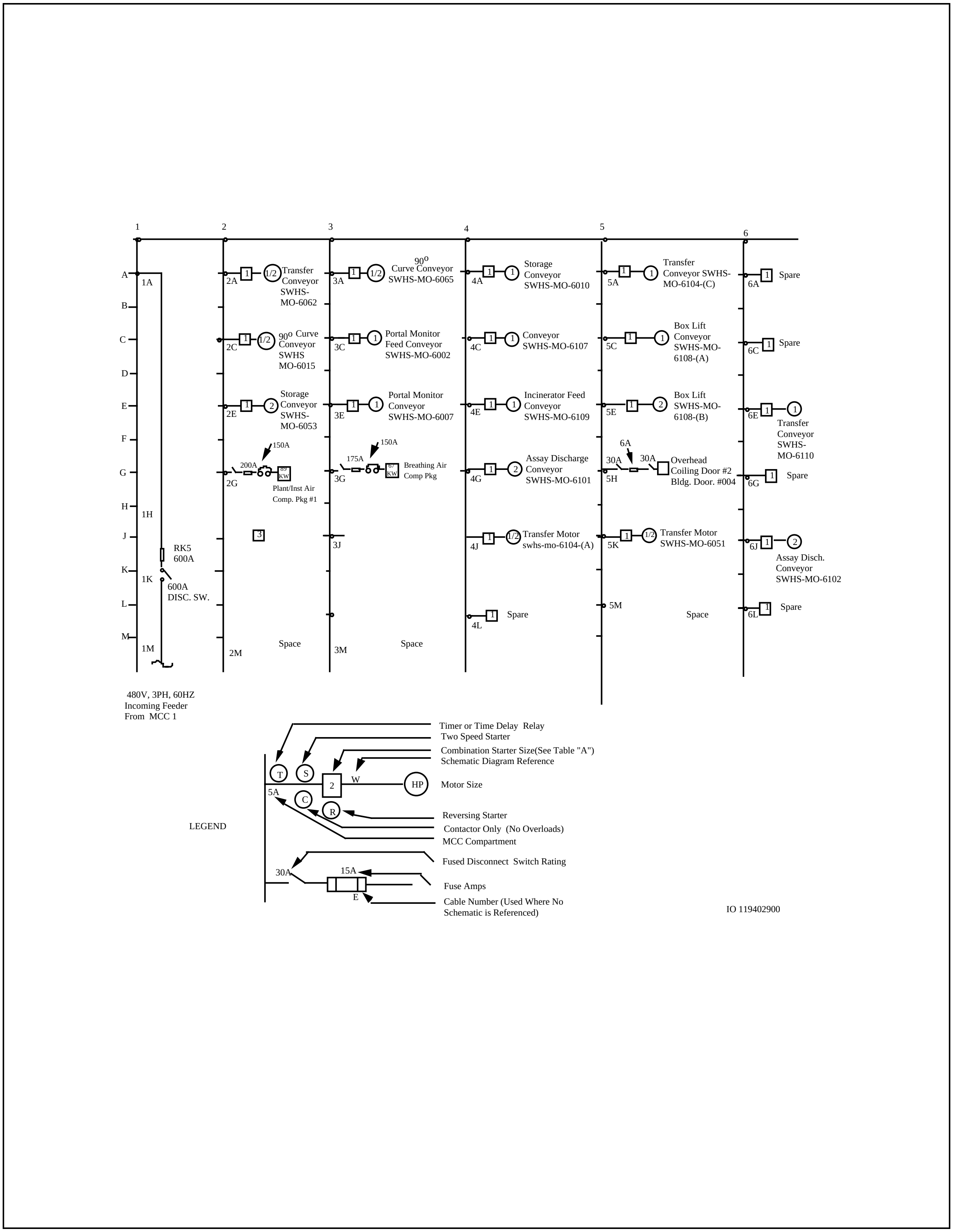


Figure 10 MCC 2

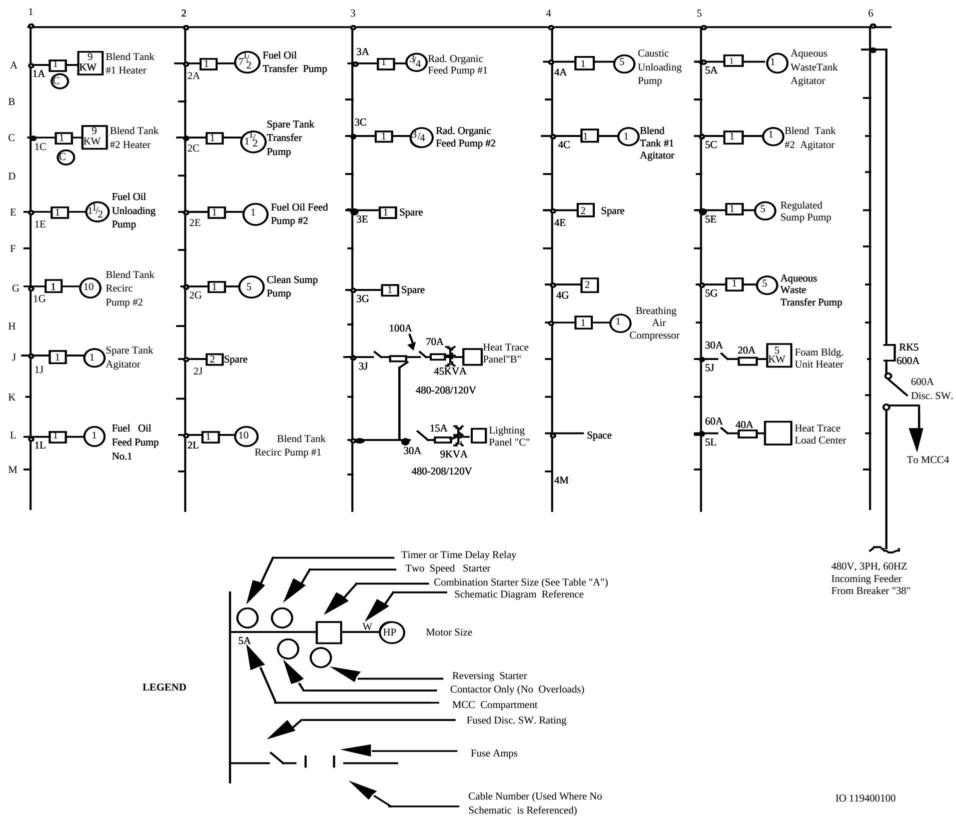


Figure 11 MCC 3

MCC 3 feeds CIF tank farm loads. These loads are blend waste tank heaters, waste tank agitators, fuel oil and caustic unloading pumps, tank farm sump pumps, waste transfer pumps, feed pumps, and heat trace panels. MCC 3 also feeds the plant and breathing air compressors #2. MCC 3 is fed by substation breaker H-261-ELNA-BKR-3B. Two cables per phase are run from the substation breaker to the line side of MCC-3 600A main disconnect.

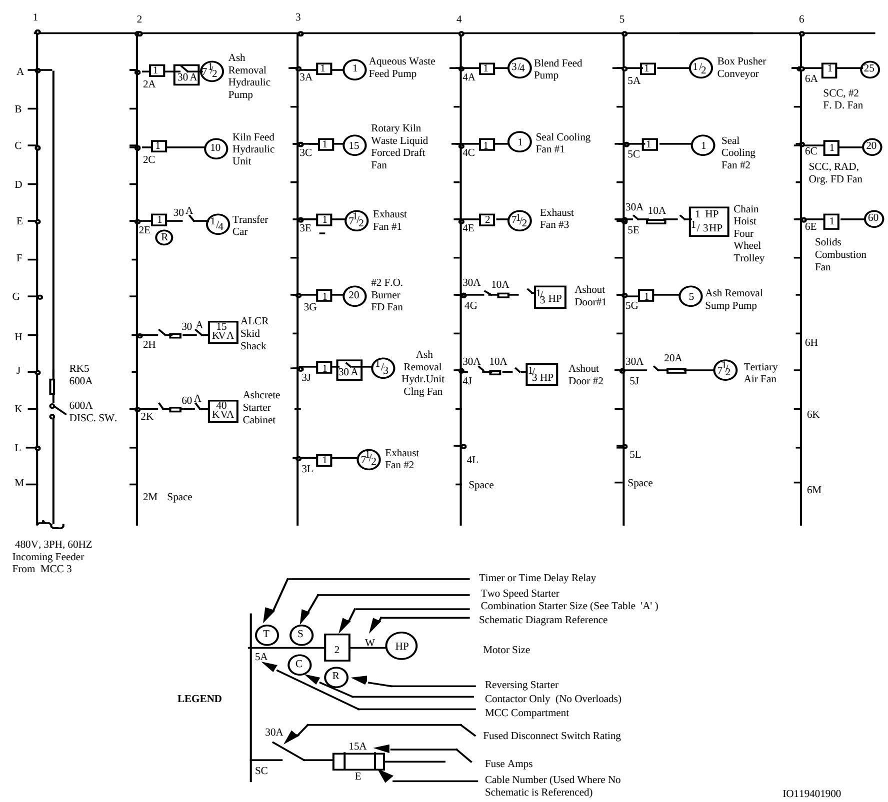


Figure 12 MCC 4

MCC 4 primarily feeds the Incinerator and Ash Handling systems. Some of the loads include forced draft burner fans, skid-mounted aqueous waste feed pump, skid-mounted blend waste feed pump, and exhaust fans. Two cables per phase are jumpered to MCC 4 from the line side of MCC 3 600A main disconnect switch.

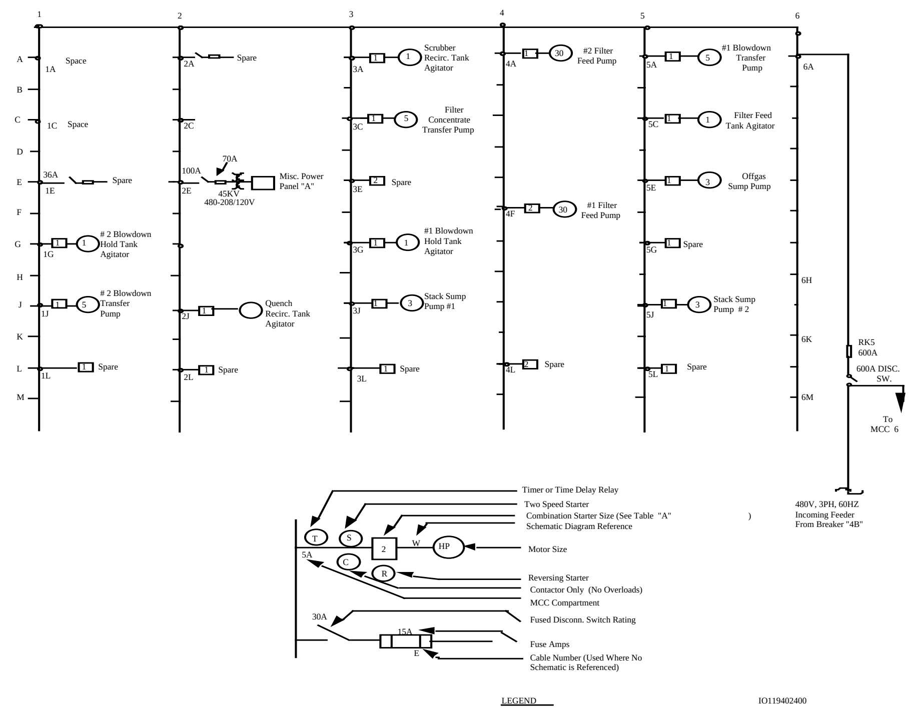


Figure 13 MCC 5

MCC 5 primarily feeds the OffGas System loads. Some of the loads for MCC 5 are OffGas tank agitators, filter feed pumps, blowdown transfer pumps, and sump pumps. MCC 5 is fed by CIF substation breaker H-261-ELNA-BKR-4B. Two cables per phase are run from substation breaker H-261-ELNA-BKR-4B to the line side of MCC-5 600A main disconnect switch.

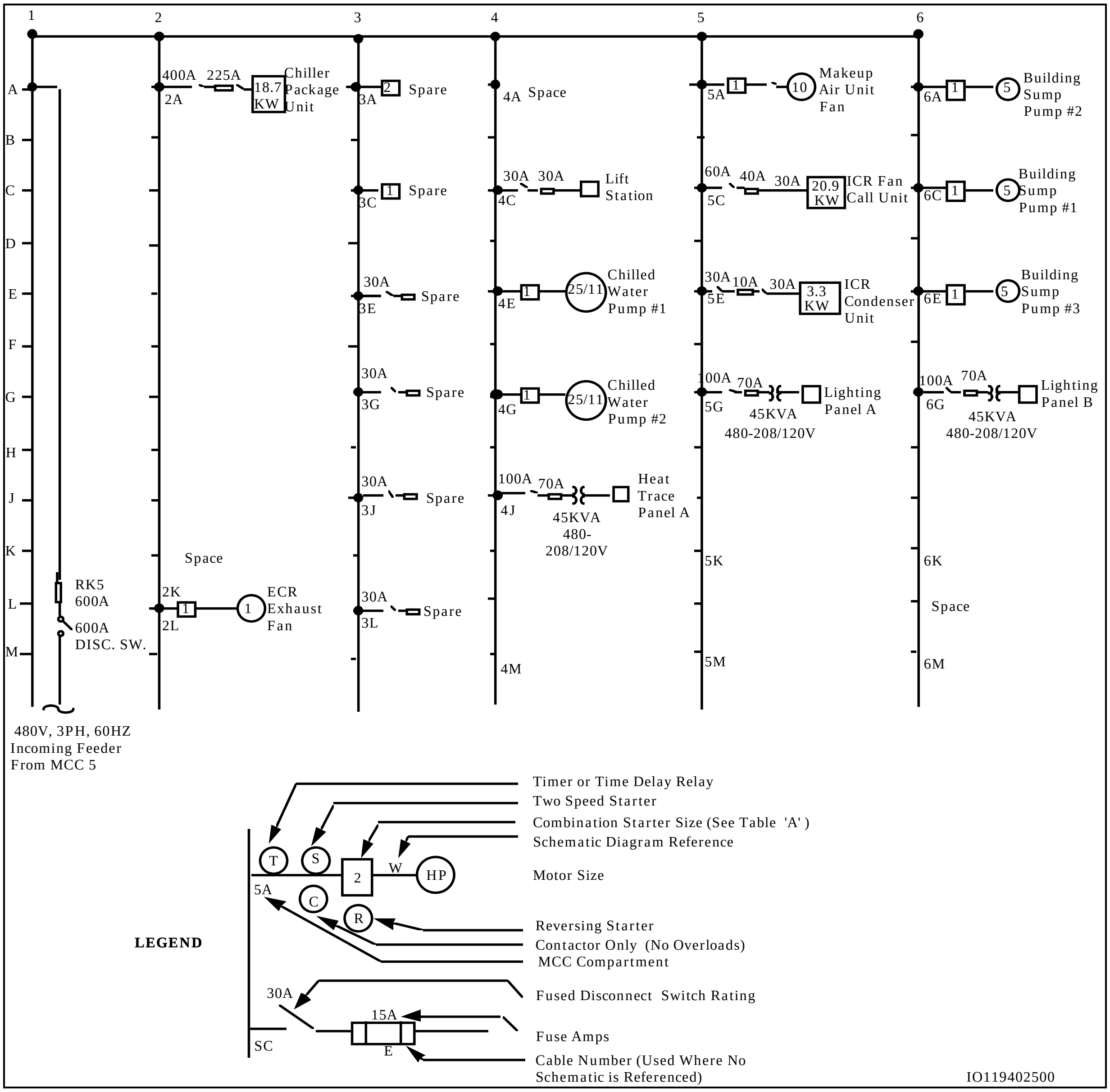


Figure 14 MCC 6

MCC 6 primarily feeds common equipment including the chiller, chiller pumps, heat trace panels, Control Room HVAC, sump pumps, and lighting panels. Two cables per phase are jumpered to MCC 6 from the line side of MCC-5, 600A main disconnect switch.

MCC 7 primarily feeds equipment or instrumentation requiring backup power. Loads include two induced draft fans, normal feed for the UPS, one (1) main building exhaust fan, and the service water pump #2 and diesel generator #2 power panel. MCC 7 is fed from the load side of ATS 2. Three cables per phase are run from ATS 2 to the line side of MCC-7 800A main disconnect switch.

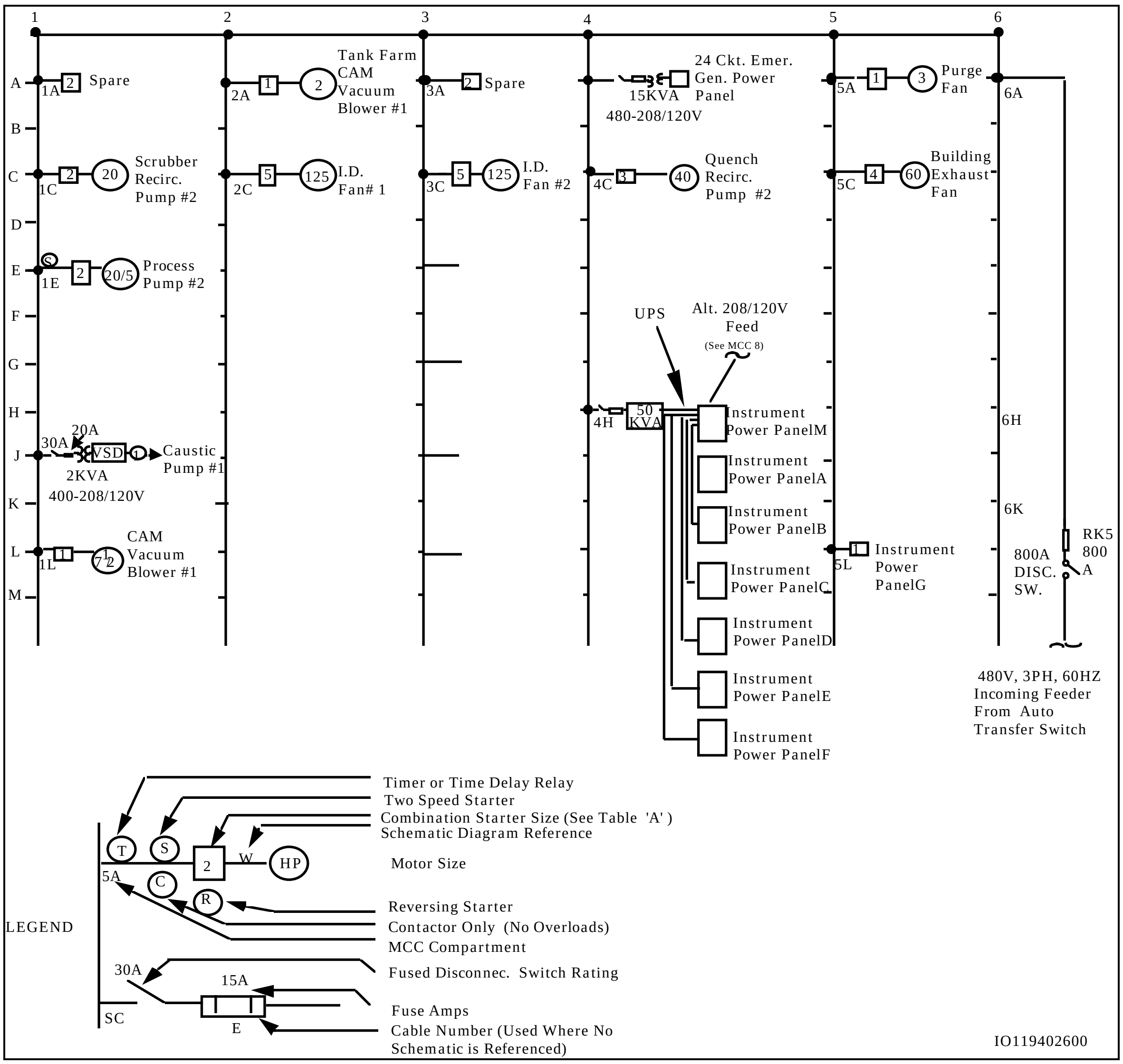


Figure 15 MCC 7

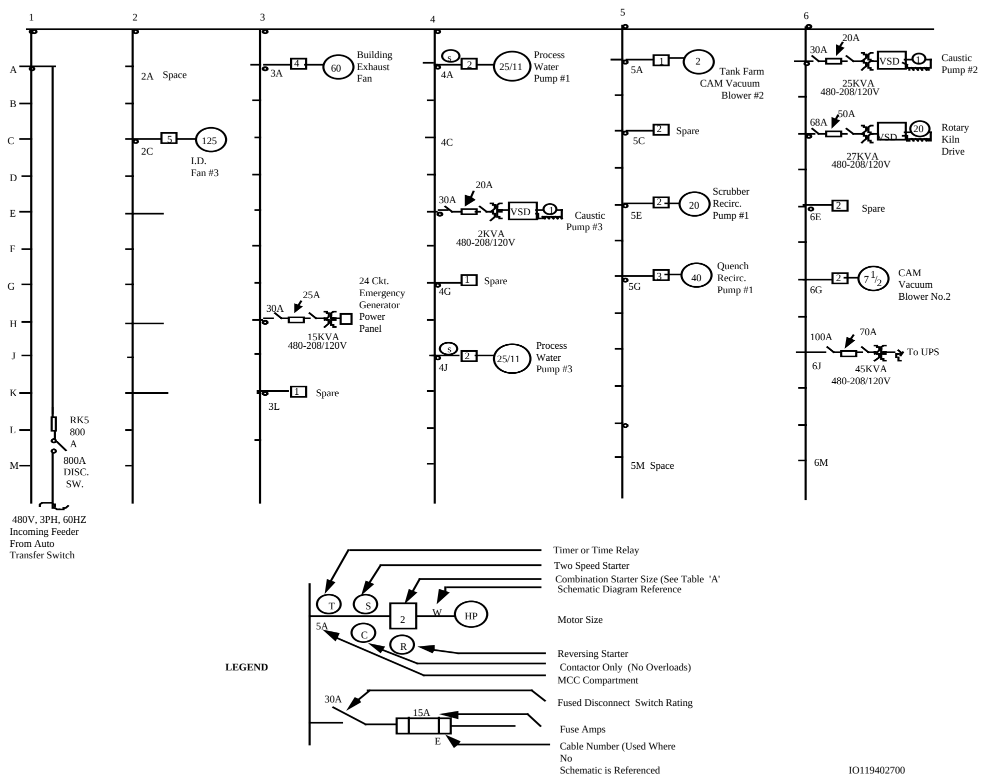


Figure 16 MCC 8

MCC 8 primarily feeds equipment or instrumentation requiring backup power. Loads include an induced draft fan, one (1) main building exhaust fan, the UPS maintenance bypass, service water pumps #1 and #3, and diesel generator #1 power panel. MCC 8 is fed from the load side of ATS 1. Three cables per phase are run from ATS 1 to the line side of MCC-8 800A main disconnect switch.

Standby Diesel Generators (SDGs)

Many plant loads require backup, or standby, power that can rapidly assume essential loads. For CIF process equipment, all standby power is produced by diesel generators. Standby power is supplied through ATSs, which automatically transfer loads to standby power upon sensing the loss of voltage from the normal or alternate power source.

For the CIF, all standby diesel generators are normally idle and must be started after receiving a signal from the essential load ATS that has lost voltage (power). A specific time period (typically 15 seconds) is required to bring the diesel generators to a point where they can assume load; therefore, all loads supplied by the MCC that has lost normal power are lost until power is restored. Depending upon the type of control devices that are normally used to start the load, it is necessary to restart some of the essential loads when switching from normal to standby power (or from standby to normal power). In general, loads fed directly from the MCC do not require manual restart when standby power becomes available if the load is controlled by a LVR circuit. This will be covered in more detail in a later section of this study guide.

Two standby diesel generators are used to feed standby power to MCCs, as noted in Figure 5. These specific standby diesel generators are discussed in the *Standby Diesel Generators Student Study Guide*, ZIOITX10, Rev. 1. Refer to Figure 17 *SDG Control Panel* for a typical standby diesel generator control panel. For automatically starting the SDG from a start signal from an automatic transfer switch, the Engine Control Switch (ECS) must be placed in the Auto position.

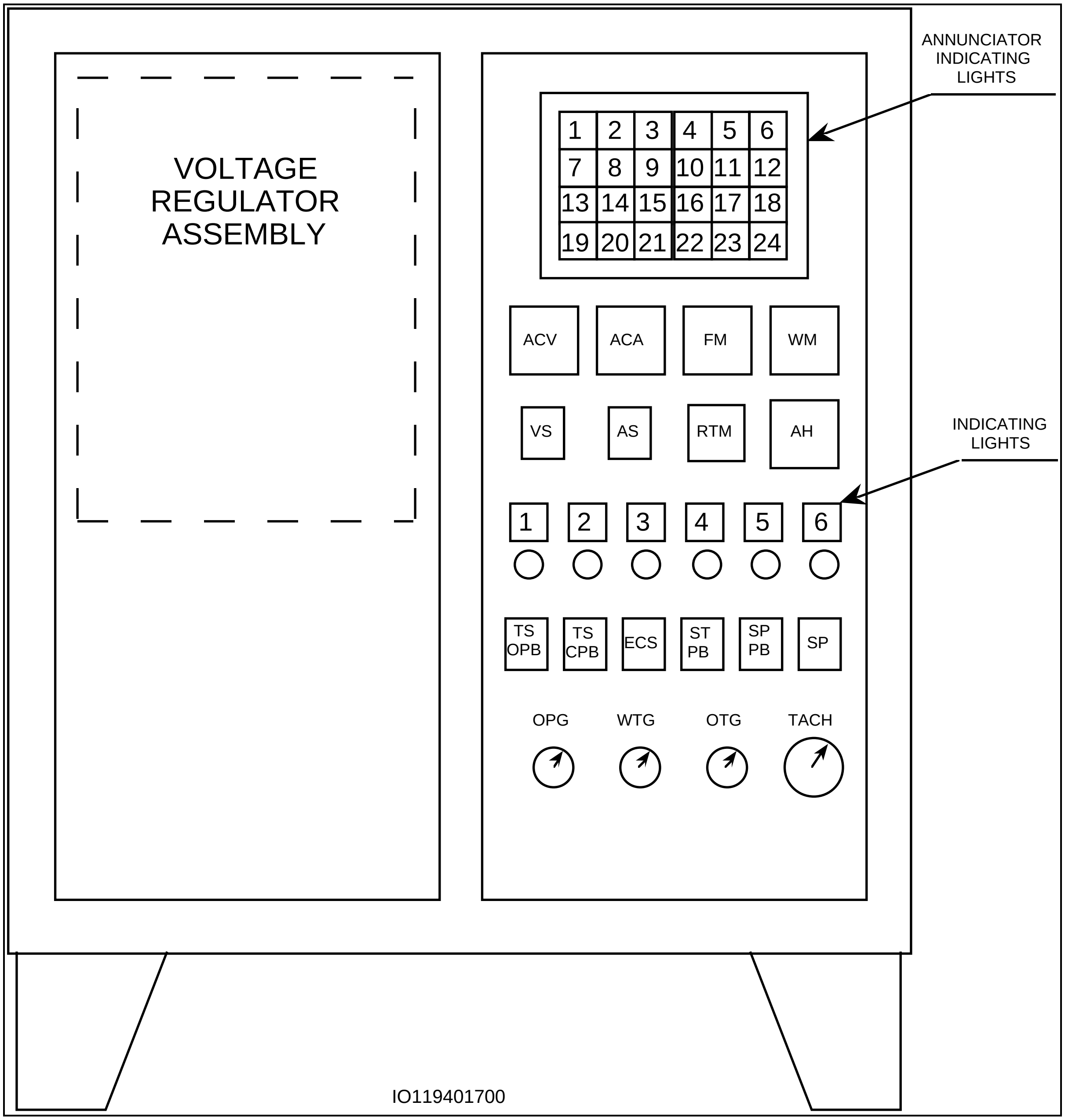


Figure 17 SDG Control Panel

Automatic Transfer Switches (ATSs)

For those MCCs that feed loads essential to the process, the source of power to the MCC is transferred from normal to the SDG by an ATS. CIF ATSs are configured so that power is provided to the MCC automatically from a breaker connected to the output of a standby diesel generator when normal power is lost. Built-in time delays or voltage-and frequency-sensing circuits in the ATSs and in the SDG permit time for the standby diesel generators to start and reach the normal output rating before supplying power to the essential loads of the MCCs.

Once normal power has been restored, the ATS may or may not require manually switching back to the normal power supply source. Manually switching an ATS from standby to normal power after normal power becomes available is required if the ATS is a "power-seeking" type. Switching an ATS from standby power to normal power when normal power becomes available is automatic when the ATS is a "normal-seeking" type.

For either a power-seeking or normal-seeking ATS, certain tasks are required to ensure that the standby diesel generator is properly shut down and ready for the next time supply standby electrical power is needed.

A control panel is provided for each ATS. The ATS control panel provides controls for normal operation and testing of the ATS, and displays the ATS status. Normally, the ATS is controlled automatically based on voltage-sensing devices that are connected to the primary source of power and to the standby source of power.

(Refer to Figure 18 *ATS 001, ATS 02 Control Panel.*) By placing the selector switch in the Manual Retransfer position, the ATS functions as a power-seeking ATS. When in the Automatic Retransfer position, the ATS is normal-seeking.

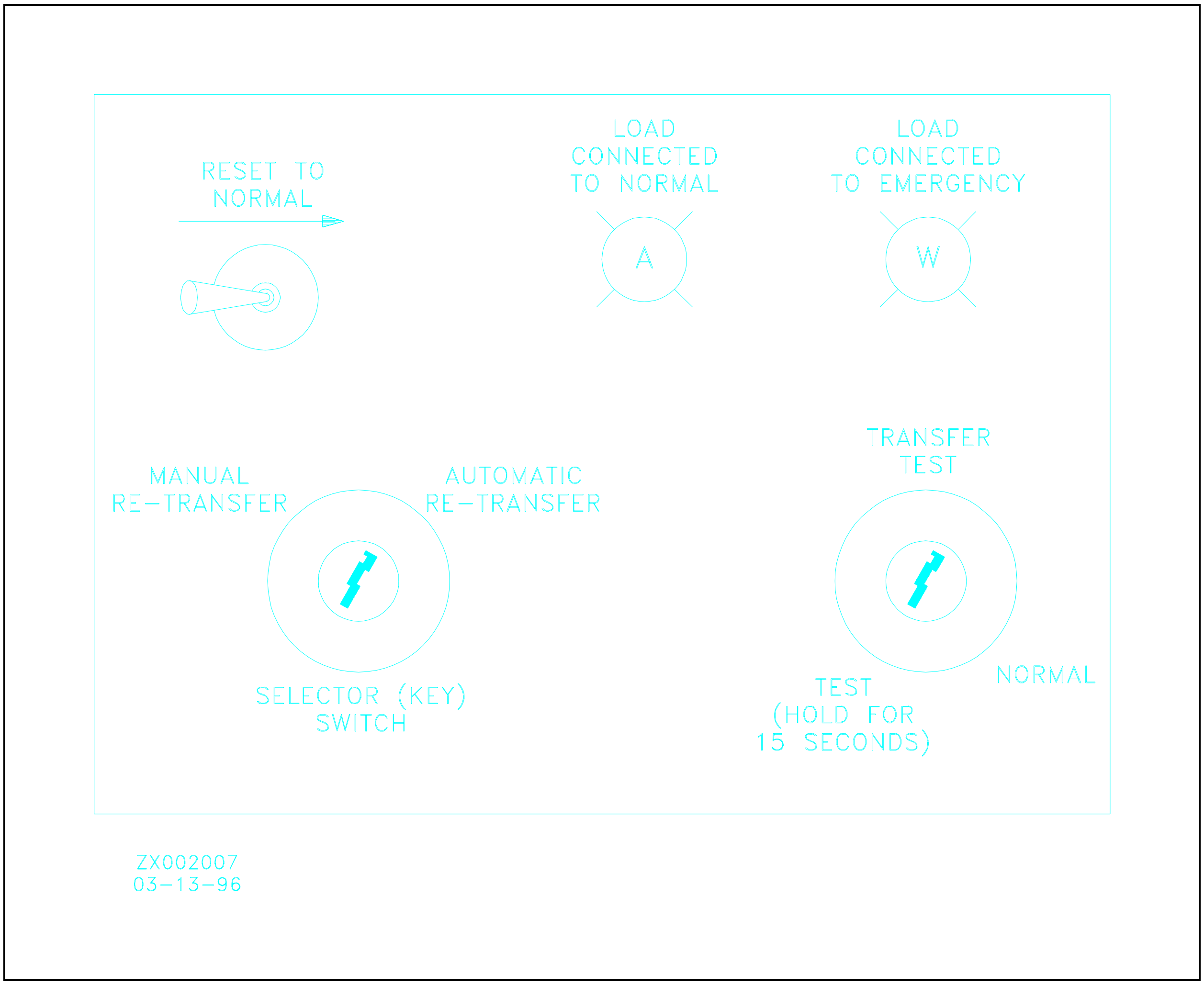


Figure 18 Automatic Transfer Switch ATS-001, ATS-002 Control Panel

The ATSs operate differently when controls are aligned as follows:

1. Selector switch in Automatic Retransfer position (normal position for operation):
   a) On loss of power (LOP), ATS waits one (1) second before starting the standby diesel generator (SDG).
   b) When the SDG output is within specification for both voltage and frequency, the ATS automatically switches the power supply from the normal source (or off) to the SDG.
   c) On return of normal power, the ATS will not retransfer to the normal source unless the normal voltage supply remains above 85% of normal for 30 minutes. This ensures that the normal source is stable.
   d) Upon transferring critical loads back to the normal power source, the ATS will automatically stop the SDG after a 5-minute cool-down delay.

2. Selector Switch in “Manual Retransfer” position:
   a) On loss of power (LOP), ATS waits one (1) second before starting the standby diesel generator (SDG).
   b) When the SDG output is within specification for both voltage and frequency, the ATS automatically switches the power supply from the normal source (or off) to the SDG.
   c) On return of normal power, the operator must place the RESET to NORMAL toggle switch in the right hand position and hold the toggle in that position until the loads are transferred from the SDG back to the normal source. This transfer can be accomplished at any time after normal power returns.
   d) After the ATS is supplying power to the loads from the normal source, the ATS will automatically shut down the SDG after a 5-minute cool-down period.

Automatic transfer switches contain the following components mounted inside of the cabinet:

- Two three-pole contactors:, one for connecting loads to the NORMAL source, one for the SDG.
- Several timing relays:
  - One 1-second delay to start SDG
  - One 30-minute delay transferring from SDG back to normal
  - One 5-minute delay to stop the SDG after returning to the normal supply
- Interlocking controls to ensure the both normal and SDG contactors can <u>not</u> be on at the same time.
- Voltage Sensors - Sense the applied voltage either from the NORMAL source, or from the SDG source. Loss of power is sensed by these voltage sensors.
- Synchronizer relay-if switching from SDG to normal, this relay ensures normal power will not be applied if there is a residual voltage on the system.
- Control compartments are mounted on the cover.

UPS Subsystem

(See Figure 19, *UPS System Block Diagram.*) The UPS is located on the south side of the EER. The UPS’s primary function is to provide conditioned 120/208 VAC single-phase or three-phase power for sensitive instrument loads and equipment in DCS boundaries. The DCS boundaries includes MLCs, Area Control Stations, Engineering Work Station, Foreign Device Interfaces, Instrument Control Cabinets (ICCs), Modicon Programmable Logic Controllers (PLCs), Input/Output (PLC I/O) Cabinets, and the VAX. The UPS batteries are sized to allow the UPS to supply rated power (up to 40 KW, or 50 KVA at 0.8 power factor [pf]) for 15 minutes.

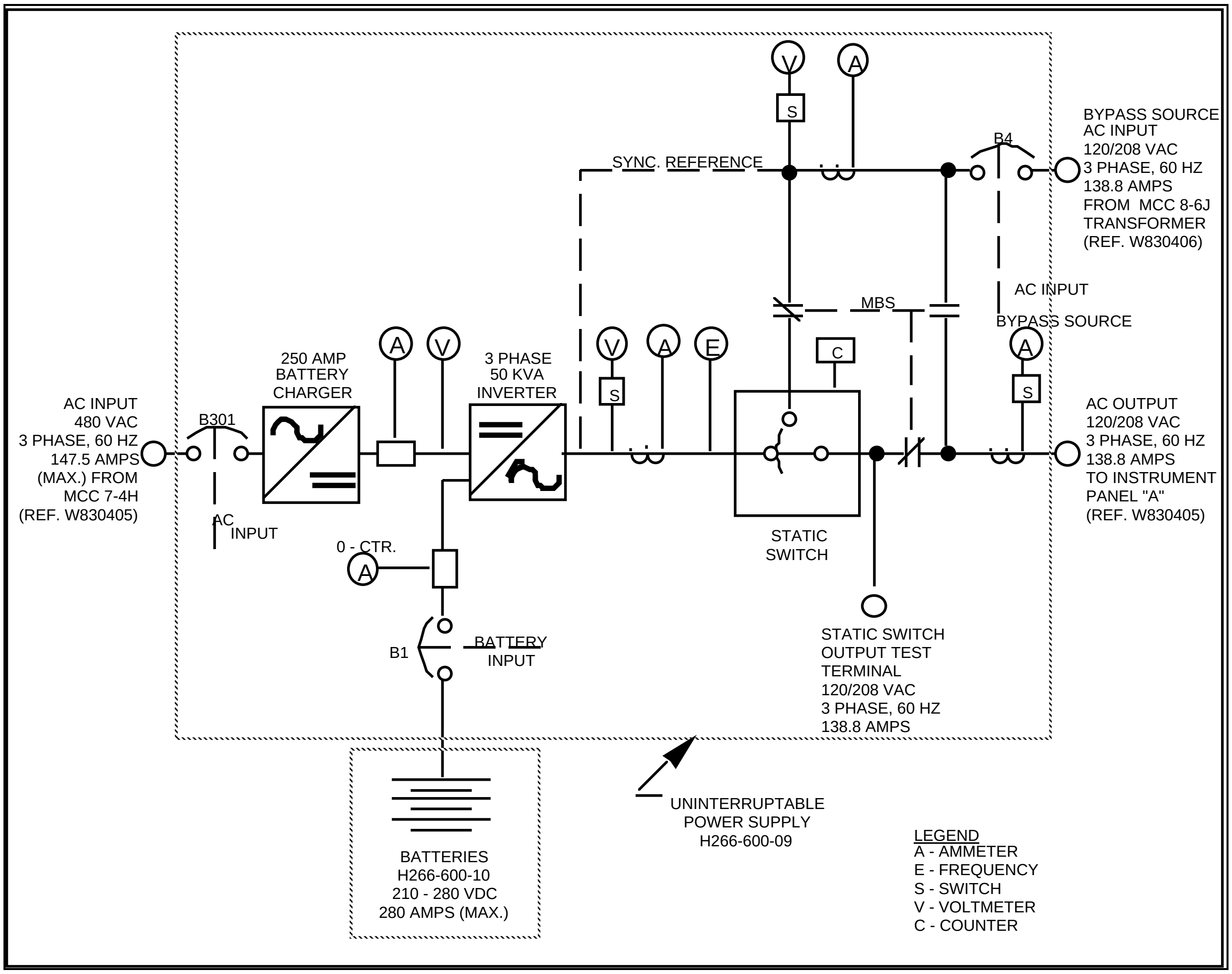


Figure 19 UPS System One-Line

The UPS inverter or alternate power source feeds Instrument Panel M. Instrument Panel M is the main distribution panel for the other six (6) instrument panels: A, B, C, D, E and F. Panels are located throughout the facility in the vicinity of the equipment which they feed. A seventh instrument power panel is IPP G. IPP G is not supported by UPS power but via a manual transformer switch fed from MCC 7, Cubicle 5L and MCC 8, Cubicle 6E.

A series of single-cell batteries power the critical loads for approximately 30 seconds until the standby diesel generator starts and loads. The UPS will receive power from the diesel generator once the generator is on-line and distributing power.

The major UPS components are as follows:

- Input Transformer
- Battery Charger
- Battery Bank
- DC to AC Inverter
- Static Transfer Switch
- Manual Bypass Switch

The following is a brief description of the listed components:

Input Transformer

The input transformer receives 480 VAC, 3-phase input power from MCC 7 Cubicle 5L and steps down this power. The input transformer also acts to isolate the AC system ground from the DC output. The input transformer is located within the UPS battery charger cabinet.

Battery Charger

The battery charger section is designed to convert the AC input voltage to a regulated DC output voltage. The AC-to-DC conversion is accomplished by using a phase-controlled rectifier which allows precise regulation of the output DC voltage. The DC is then used to charge the battery and to supply the inverter with input power. A phase-controlled rectifier is used since it is able to maintain a constant DC bus voltage with a variable AC input. The battery charger DC filter is an inductor and capacitor circuit that functions to smooth the voltage from the rectifier.

Battery Bank

The battery bank provides DC input power to the inverter when the rectifier output drops below a design voltage. The UPS uses a battery bank consisting of multiple single-cell batteries. The battery bank can deliver rated power through the inverter to the electrical loads for approximately 15 minutes. The battery bank is automatically recharged when the standby diesel generator starts and loads or after normal power has been restored.

When the standby diesel generator starts and loads or normal power is restored, the battery charger output voltage will provide DC power to the critical loads and sufficient power to recharge the battery bank.

The battery bank consists of lead acid batteries. The batteries provide long life and are easily recharged.

DC to AC Inverter

The DC to AC inverter is designed to convert the DC voltage coming from the battery charger section to a regulated AC output voltage. The DC-to-AC conversion is accomplished by using a square wave inverter with its necessary controls and regulating output transformer.

The square wave inverter utilizes silicon controlled rectifiers (SCRs) to convert the DC to AC. The SCRs receive alternate "turn-on" pulses from the inverter control assembly. The alternating pulses cause alternating conduction of the SCRs which applies the DC input voltage alternately to the load, thus producing an alternating current in the load.

The square wave output from the inverter is shaped and voltage is regulated by a series of output reactors and transformers to provide a sine wave voltage at the correct magnitude to the critical loads.

Static Transfer Switch

The function of the static transfer switch is to provide an automatic transfer, without interruption, from the output of the inverter to the bypass source in the event of an overload on the UPS output, an inverter failure, or loss of the AC voltage from the input transformer. In addition to automatic transfer, the static transfer switch can be used to manually transfer the load from the inverter to the bypass source if necessary.

The static transfer switch has an electronic circuit designed to initiate an automatic transfer to the bypass source if it detects a low VAC input from the inverter, deterioration of inverter square wave, or a load fault on the UPS loadside.

The static transfer switch also senses current. Because the output of the inverter is current-limited by design, any fault or overload that is applied to the inverter will cause the output voltage of the inverter to go low. The static transfer switch senses the low output voltage and automatically switches to the bypass source. The current-sensing circuitry is designed to transfer from the inverter to the bypass source at 120% overload.

Manual Bypass Switch

The manual bypass switch (MBS) is used typically during inspections or maintenance. By placing the MBS in the Bypass to Load position, the UPS inverter and static transfer switch are bypassed.

Variable Speed Drives

Most of the CIF mechanical devices are driven by standard AC induction motors that are designed to run at almost constant speed. For special drives, such as the caustic pumps and the rotary kiln drive, a variable speed is required. For these special applications DC motors are used instead of AC motors. (Refer to Figure 20 *Reliance VS Drive)*)

The caustic pump DC motors require a source of DC voltage. By varying the DC voltage to a DC motor, the speed can be changed. Typically, two pieces of electrical equipment are required: An AC transformer that converts the AC voltage to the correct voltage required by the DC drive, and an AC to DC converter. The AC to DC conversion is accomplished via a Reliance VS drive.

The drive shown on Figure 20, converts AC to DC for the DC motor field and for the DC motor rotor (armature). By adjusting the main dial from zero (0) to ten (10), the DC motor speed can be adjusted from zero speed to full speed.

The transformers that are mounted directly ahead of the VS drives are fed by either MCC 7 or MCC 8, so these drives do have a source of standby power.

The kiln also requires a DC drive motor. An Allen-Bradley control unit for the kiln drive is as shown on Figure 20A, *Allen Bradley Kiln Drive.*.

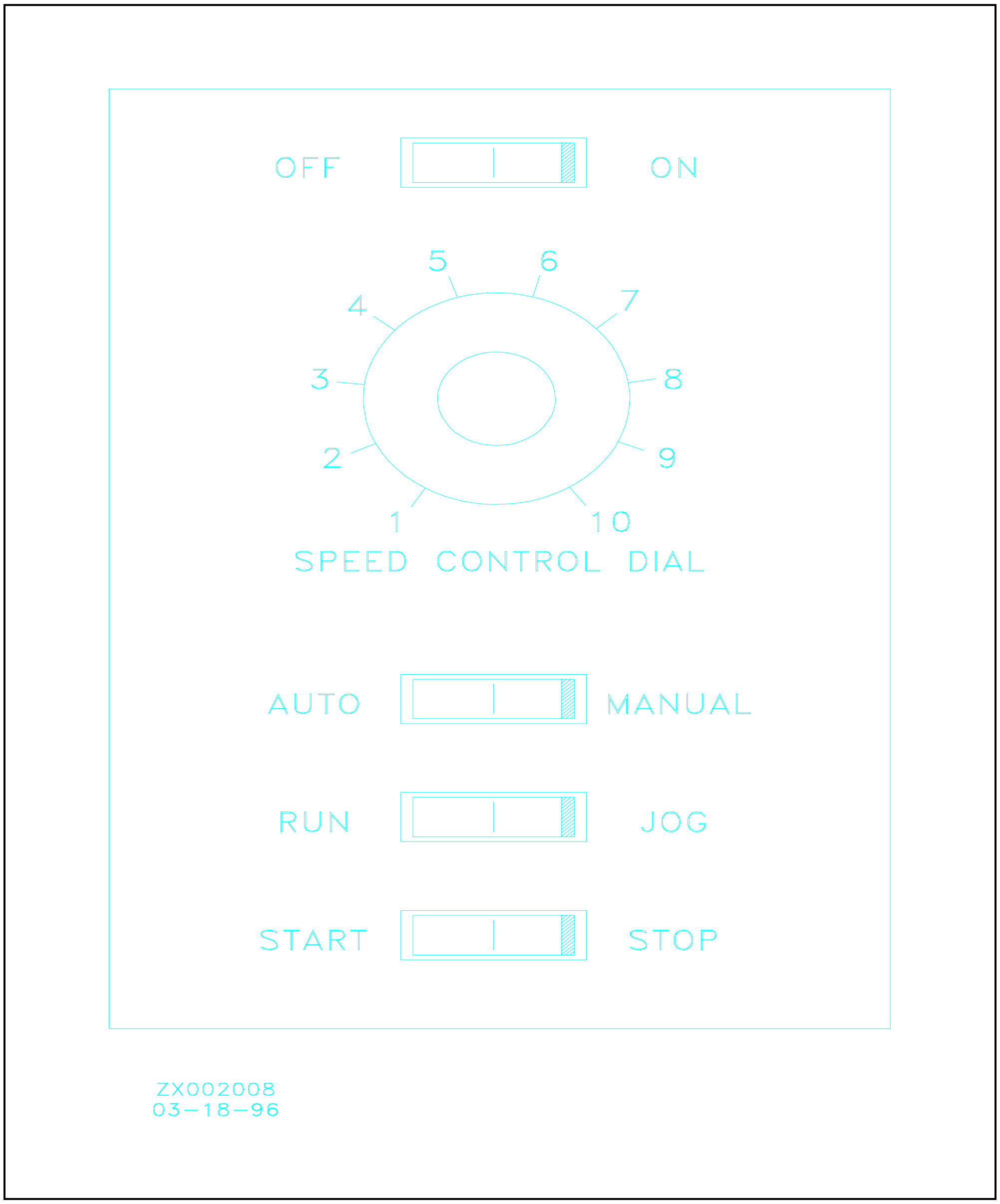


Figure 20 Reliance VS Drive for Caustic System

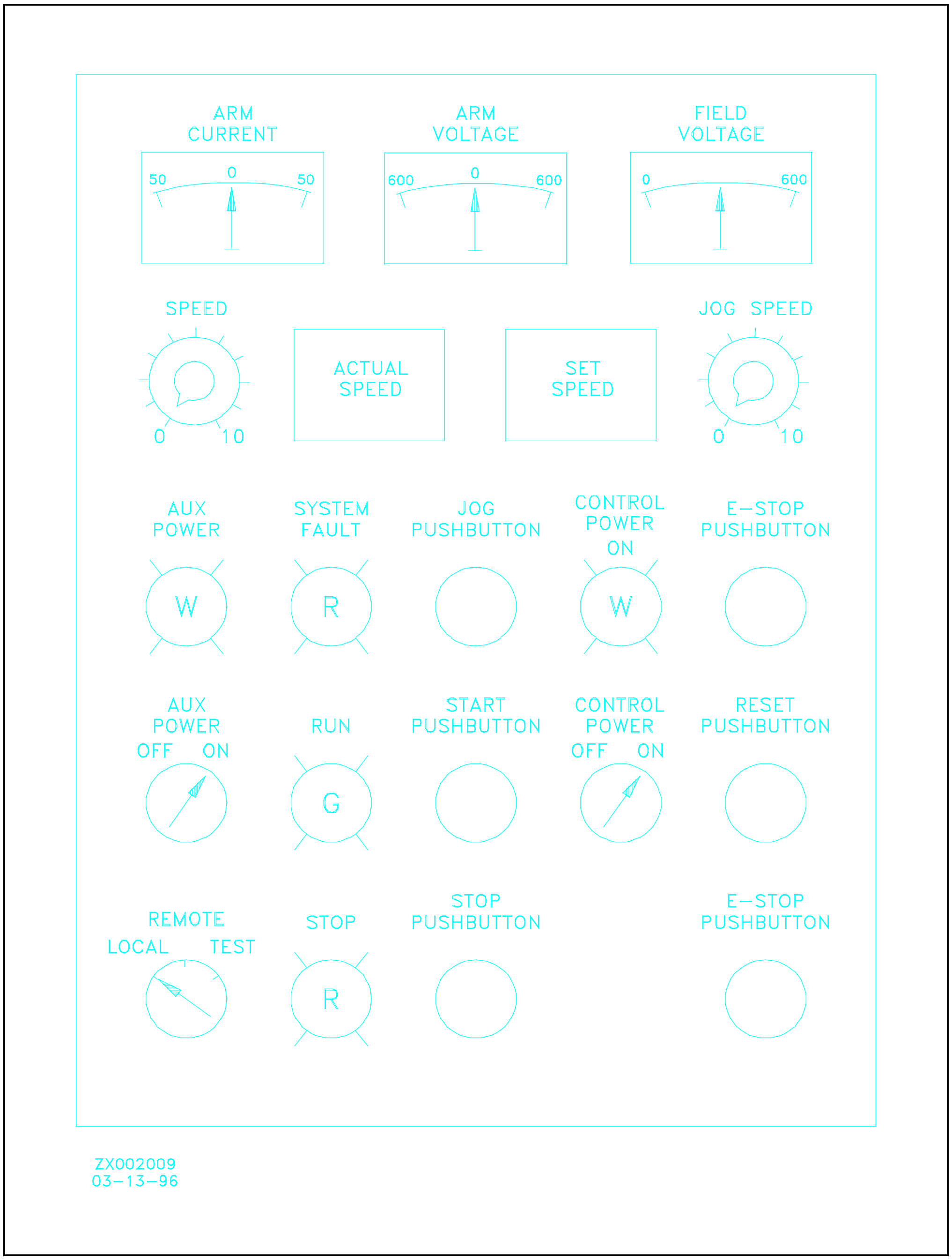


Figure 20A Allen Bradley Kiln Drive

Safety Switches

Safety switches are mechanically operated switches that are used to locally isolate loads from the loads' power supplies. Safety switches are used for loads such as power transformers, motors, or self-contained air conditioners. Safety switches are mounted directly in the power lines feeding a load. Safety switches may be fused or un-fused. For a typical safety switch, refer to Figure 21, *Disconnect Switch.* A special three-position switch, MTS-001, is used to feed EEP Pnl. IG from either MCC 7 or MCC 8.

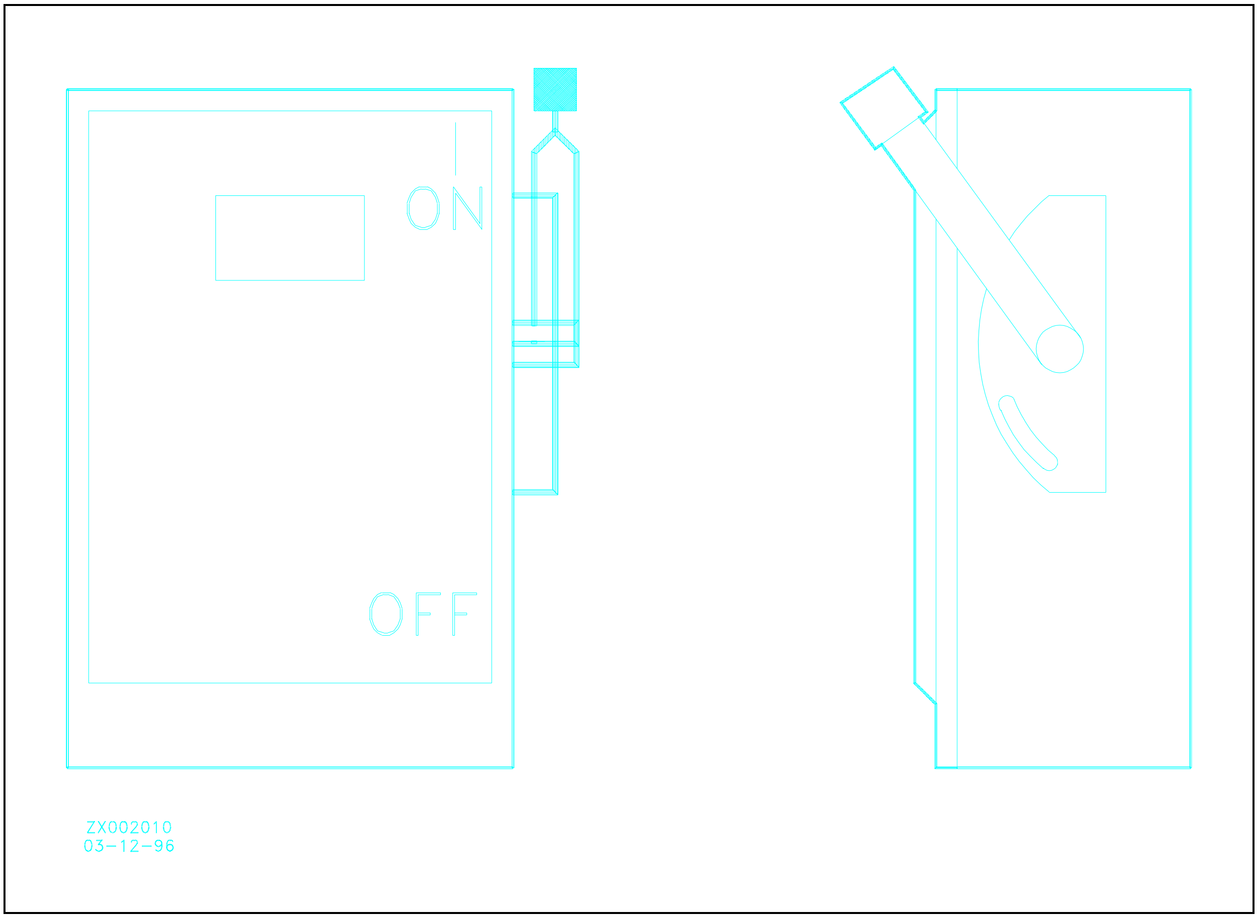


Figure 21 Disconnect Switch

480 Volt to 120/208 Volt Power Transformers

Small power transformers step the voltage output from MCC compartment feeders down from 480 VAC to voltage levels suitable for lighting, instrumentation, heat trace circuits, and other small loads. Typically, transformers used at the CIF are rated for a 480-VAC primary to a 120/208-VAC secondary. This means that on the secondary, any line (phase) to ground voltage will be 120 VAC, and any line-to-line (phase-to-phase) voltage will be 208 VAC. These transformers are suitable for either indoor or outdoor duty and are typically mounted on walls, on poles, or on the floor, as close as possible to the loads being fed. The safety switch is used as a local disconnect for the transformer. The 120/208-VAC outputs from transformers are usually directed to panel boards.

Panel boards

Panel boards used in the CIF are similar to those used in residential houses with the exception that most CIF panel boards are three-phase, 120/208 volts. Panel boards are used to distribute power to 120-volt loads; typically lighting, instruments, relay cabinets, heat tracing, fire alarm panels, monitors, sampling systems, valves, analyzers, and small self-contained air conditioners.

Panel boards contain manually operated breakers. A loss of incoming line power to the panel boards does not require operator action upon restoration of power. Panel boards are typically fed from nearby, separately mounted 480-volt to 120/208-volt power transformers.

Refer to Table 2, *Panel Boards and Transformers* for a tabulation of panel boards and their associated transformers, and the designations regarding the subsystem to which each panel board is assigned.

MCC #	MCC COMPTMT	Transformer Rating in KVA	Tx Rating if other than 3 Phase 480VAC Input to 208/120 VAC Output	Panel Board Designation	Panel Board I.D.
1	3L	15		Power Panel B	ELLV-PNL-005
3	3G	45		Heat Trace B	HTTR-PNL-002
	3G	30		Heat Trace C	HTTR-PNL-004
	3G	9		Lighting C	ELLV-PNL-003
	5L	15		Heat Trace Load Center	HTTR-PNL-003
5	2E	45		Power Panel A	ELLV-PNL-004
6	4G	45		Heat Trace A	HTTR-PNL-001
		30		Heat Trace D	HTTR-PNL-005
	5G	45		Lighting A	ELLV-PNL-001
	6G	45		Lighting B	ELLV-PNL-002
7	4A	15		Emergency Generator Power Panel	EEP-PNL-002
	4H	50 KVA UPS or		Inst. Power Panel M	UPS-PNL-IM
		45 KVA TX			
	4H via UPS Panel IM	---		Inst. Pwr Panel A	UPS-PNL-IA
	4H via UPS Panel IM			Inst. Pwr Panel B	UPS-PNL-IB
	4H via UPS Panel IM			Inst. Pwr Panel C	UPS-PNL-IC
	4H via UPS Panel IM			Inst. Pwr Panel D	UPS-PNL-ID
	4H via UPS Panel IM			Inst. Pwr Panel E	UPS-PNL-IE
	4H via UPS Panel IM	9	TX input is 208VAC from UPS-PNL-IM	Inst. Pwr Panel F	UPS-PNL-IF
7	*5L	30		Inst. Pwr Panel G	EEP-PNL-IG
8	3J	15		Em. Generator Power Panel	EEP-PNL-001
	*6E	30		Inst. Pwr Panel G	EEP-PNL-IG

Table 2 Panel Boards and Transformers (Txs)

*EEP-PNL-IG (Instrument Power Panel G) has two sources of power. Either source can be accessed by means of manual transfer switch H-261-EEP-MTS-001.

Summary

- By knowing how major components work functionally, an understanding of how power is controlled and how power can be monitored can be achieved. The facility has attempted to help the operators' understanding by coding the various sub-system component nameplates. The following breaks down the six subsystems into major components:
- ELNA 13.8Kv to 480 VAC Substation (including switchgear)
- ELNH All Motor Control Centers (MCCs) and 480VAC panels
- EEP Diesel generators, ATSs, SDG panel boards 001 and 002, and instrument panels IG.
- UPS UPS System, and instrument panels IA, IB, IC, ID, IE, IF, IM
- HTTR Heat trace panels 001, 002, 004, 005 and heat trace load center 003.
- ELLV Lighting panel boards and power panel boards 001, 002, 003, 004, 005.

INSTRUMENTATION, ALARMS, AND CONTROLS

Electrical Instrumentation and Control can vary from simple on-off controls to elaborate control schemes. Instrumentation can be simple, as in the case of panel boards, or extensive, as in the case of the UPS.

4.01 DESCRIBE the proper operation of the 480 VAC Distribution Substation switchgear and its components, controls, indicators and instrumentation (ELNA Subsystem)

4.02 DESCRIBE the proper operation of the Motor Control Centers (MCCs) and their components, controls, indicators and instrumentation (EHNH Subsystem).

4.03 DESCRIBE the proper operation of the automatic transfer switches (STSs), and their components, controls and indicators. (Part of EEP Subsystem)

4.04 DESCRIBE the proper operation of the Uninterruptable Power Supply (UPS), and each of the UPS major components, the UPS controls, instrumentation and alarms. (Part of the UPS Subsystem).

4.05 DESCRIBE the proper operation of the VS Drives and their controls and instrumentation.

4.06 DESCRIBE how the following components are energized and de-energized:

a. Safety switches

b. 480 to 208/120 VAC transformers

c. Panel boards

d. Standby diesel generator (Automatic mode only)

ELNA Subsystem Instrumentation

The substation transformer has local gauges to monitor for oil level, oil temperature, pressure-vacuum gauge, and winding temperature gauge. These gauges have contacts to provide the DCS with general alarm indication.

The substation transformer also has a pressure relief device and a rapid-pressure rise relay which provides the DCS with general alarm-condition indication. The transformer has a winding temperature gauge known as a dial hot spot thermometer. The dial hot-spot thermometer indicates the hottest spot temperature of the transformer windings.

An ammeter, voltmeter, and the watt-hour meter, which are located on compartment 1A of the switchgear front panel, monitor the main bus. The ammeter has a range of 0 to 3000A measured in 50-A increments. An ammeter selector switch located on compartment 1A front panel allows an operator to choose A-, B- or C-phase current to be monitored on the main bus ammeter. The main bus ammeter receives its input from one of the three 3000A/5A current transformers (Cts) monitoring the main bus. The voltmeter has a range of 0 to 600V measured in 10-V increments. A voltmeter selector switch located on the compartment 1A front panel allows an operator to choose phase A to B voltage, phase B to C voltage, or phase C to A voltage to be monitored on the main bus voltmeter. The main bus voltmeter receives its input from one of the three 480V/120V potential transformers (Pts) monitoring the main bus. The voltmeter is especially useful in determining that normal power has returned after a loss of power.

The other breaker compartments have an ammeter and a selector switch. The ammeters have a range of 0 to 800A measured in 20-A increments. The selector switch allows the operator to choose which phase current to monitor on the breaker ammeter or to turn the breaker ammeter off. The signal for the breaker ammeter comes from one of three 800A/5A current transformers. These current transformers are located on the breaker load side and have a ratio of 160 to 1 (160:1). The ratio means that for an 800A real load the output is 5A to the meter. The meter has an A scale which will indicate 800A.

All of the instrumentation compartments (1A, 2A, 3A, and 4A) have an ammeter monitoring current flow through the switchgear space heater circuits. These ammeters have a range of 0 to 10A measured in 0.2-A increments and are typically energized by the Site Utilities Department when the switchgear lineup is de-energized.

DCS point tag ELNA 5409EA-1 is the only DCS point tag for the substation. This DCS point tag has one alarm, 5409EA, labeled SUBSTATION TROUBLE, which is a common trouble alarm for the 480V substation transformer. There are no DCS alarms for the 13.8 kV substation disconnect or the switchgear breakers. Upon receiving a “Substation Trouble” alarm, CIF supervision will notify H-Area Power Operations Shift Supervisor and assist H-Area Power Operations personnel as necessary.

Table 3, *Transformer Indicator with Remote Alarm Contact Setpoints*, contains the transformer indicators that can activate the DCS alarm 5409EA and the alarm setpoints. When any of the Table 1 indicators exceed or equal the alarm setpoint, its remote alarm contact opens.

480V Substation Transformer Indicator	**Alarm Setpoint**
Liquid Temperature	90 °C
Liquid Level Gauge	LO
Winding Temperature Gauge	112 °C
Vacuum-Pressure Gauge	3.5 Vacuum 7.0 psig pressure

Table 3 Transformer Indicator with Remote Alarm Setpoints

ELNA Substation Controls

The substation breakers are mounted on rails that guide the breakers into a connected or disconnected position, called “racking in” or “racking out,” respectively. When the breaker is racked in, both the power-side stabs and the load-side stabs of the breaker are connected to the substation. When racked out, the breaker is withdrawn, and the load and power stabs are disconnected. Racking out a breaker allows maintenance to be performed on the breaker or provides a lockout point for the associated load.

The breaker can also be withdrawn to a test position. Placing a breaker in test disconnects the breaker stabs from the bus bars, but maintains control circuits connected. This position is used for checking the control circuits during maintenance. No switchgear breakers in the CIF area have control circuits. Racking in and out is an E & I function.

Breaker position on the distribution substations can be monitored using the local breaker-position indication. Each breaker has a status indicator that shows either OPEN, CLOSED, or TRIPPED, depending upon the position of the breaker. A second indicator indicates if the breaker-closing mechanism is either CHARGED or DISCHARGED. These indications are operated mechanically in the breaker, and require no power for operation.

Controls for the 480-VAC distribution substation switchgear breakers are located at each switchgear assembly compartment. All feeder breakers are manually operated. A handle on the front compresses a set of springs (charges) that are used to close and trip the breaker. Each breaker contains a TRIP pushbutton, and a CLOSE button.

When a switchgear breaker trips because of an overload or a fault, a trip indicator on the front of the breaker displays TRIP. Tripped breakers should not be reclosed unless the cause of the trip can be known, understood, and corrected. This is usually a Power Department or CIF E & I function.

Motor Control Centers (ELNH) Instrumentation

Motor control centers in Building 261-H have no local instrumentation that would alert an operator of a loss of power. The first indication would be an alarm in the control room from different sub-systems that would stop when power is lost. MCC 7 and MCC 8 each have voltage sensors on the entry side of the MCC. These sensors detect a loss of voltage (power) from the substation and in turn send a signal to the DCS. These signals are H261-ELNH-E5007 and E5008 (DCS Inputs #10277 and 10278). This loss-of-power signal is used by the DCS to de-energize all the subsystem “START” signals when the subsystems are operating in the “Automatic” mode. The DCS system then can initiate a sequenced start of critical loads. Starters (motor controllers) are arranged so that any change in the status of the starter is reported by having the MCC compartment send a voltage signal to the PLC I/O cabinets that are located adjacent to each MCC.

Controls

Each MCC has a main disconnect switch that can be used to isolate the complete MCC.

Each MCC compartment is equipped with at least a load-break switch and fuses to energize/de-energize downstream loads and protect these loads from overcurrent conditions. These switches are manually operated. The handle displays a red side when the compartment is energized and a green side when the compartment is de-energized.

Some MCC compartments contain either starters or contactors (starters with no overload protection) in addition to the switch and fuses. In these cases, the starter or contactor is energized/de-energized by control devices such as a pushbutton, selector switch, a system signal, or the DCS. These control devices are typically mounted remotely from the MCC.

Whenever an MCC compartment contains an overload relay, the outside of the MCC compartment has a reset button. This reset is used to reset the overload relay in cases of serious overcurrents going to the motor.

Automatic Transfer Switches (EEP-ATS-001, 002)

Controls and instruments are as follows:

- MANUAL RE-TRANSFER, AUTOMATIC RE-TRANSFER key selector switch-selects the mode of operation for the ATS if the ATS is NORMAL SEEKING. When in AUTOMATIC RE-TRANSFER, the ATS will automatically shift to the standby power source if the normal power source is lost, and back to the normal power supply once the normal power supply is restored. When in the MANUAL RE-TRANSFER position, the ATS must be manually switched to transfer power sources from the SDG back to normal. This selector switch is normally set to the AUTOMATIC RE-TRANSFER position for the CIF ATSs.
- Reset to normal toggle switch - when the manual retransfer-automatic retransfer selector switch is in the MANUAL RE-TRANSFER position, this reset-to-normal toggle switch must be held in the right-hand position (direction of arrow) to reset the ATS from the standby diesel generator position to the normal source position. When this reset-to-normal toggle switch is activated, the ATS immediately shifts from the SDG to normal. There is no 30-minute delay to wait for the normal power source to stabilize.
- NORMAL indicates the position of the ATS when it is connected to the normal power source.
- EMERGENCY indicates the position of the ATS when it is connected to the standby diesel generator.
- Transfer/Test Key Selector Switch - can be used to load test the standby diesel generator. When in the TEST position, the voltage to the ATS voltage sensors is disconnected so the ATS "thinks" that power in the facility has been lost. The ATS proceeds through its normal cycle of starting the SDG and switching the loads from the normal source to the SDG. The Manual Retransfer-Automatic Retransfer selector switch should be in the

MANUAL RETRANSFER position if this Transfer/Test switch is in the TEST position. This selector switch presently is not used since the SDG is load-tested by using load banks.

The ATSs communicate their status to the DCS in two point tags for each ATS:

a) ATS 001 (EEP-ZI-5400A, Emergency position is point 5400WE-1)
(EEP-ZI-5400B, Normal position is point 5400WE-2)

b) ATS 002 (EEP-ZI-5404A, Emergency position is point 5404WE-1)
(EEP-ZI-5404B, Normal position is point 5404WE-2)

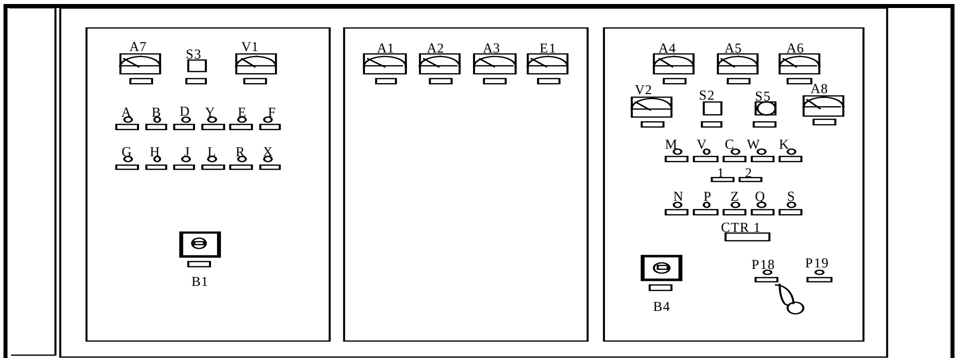
Standby Diesel Generator (EEP-DG-001, 002)

Controls, alarms and instrumentation for the standby diesel generators are covered extensively in Student Study Guide, ZIOITX10, Rev.1. For the Electrical Distribution System, it is sufficient to know that the SDG engine control switch (ECS) located on the SDG control panel must be placed in the AUTO START position. The SDG will automatically start upon receiving a signal from the associated ATS that power has been lost.

It is important to know that even if the SDG is being tested manually in the No-Load or Loaded mode, and if power in the facility is lost during the SDG test, the SDG will immediately supply the facility with power (over-riding the tests).

UPS Subsystem (DCS Display 738) Instruments, Alarms and Controls

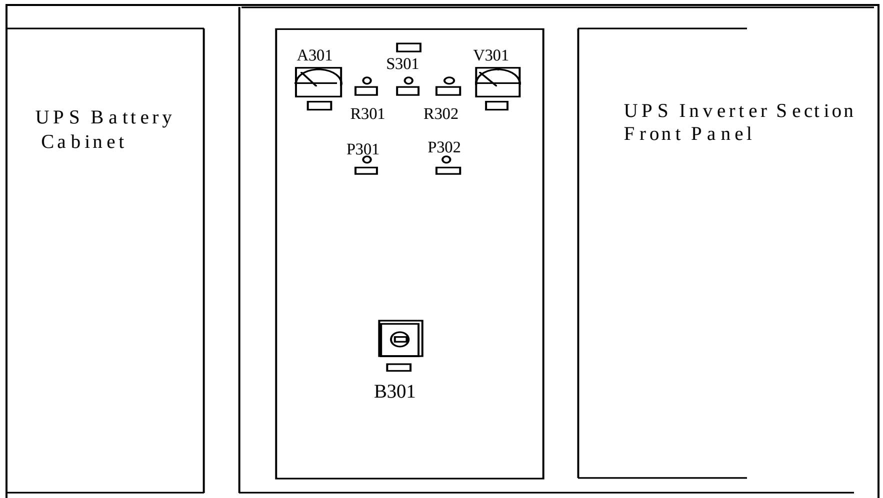
(See Figures 22 and 23, *CIF UPS Inverter Section Front Panel View*, *UPS Battery Charger Section Front Panel*). The UPS has many meters, status lights, switches and adjustable potentiometers. The meters and status lights give indications of UPS performance. The switches and adjustable potentiometers allow operators to observe and record multiple indications or to change the UPS configuration.



CIF UPS Inverter Section Front Panel View

A1	Inverter Output A	AC Ammeter
A2	Inverter Output B	AC Ammeter
A3	Inverter Output C	AC Ammeter
A4	Bypass Source AC Input A	AC Ammeter
A5	Bypass Source AC Input B	AC Ammeter
A6	Bypass Source AC Input C	AC Ammeter
A7	Battery Input Charging / Discharging (0 Center)	DC Ammeter
A8	System Output	AC Ammeter
V1	Inverter Output	AC Voltmeter
V2	Bypass Source AC Input	AC Voltmeter
E1	Inverter Output	Frequency Meter
A	Battery Input Breaker Closed	Status Light
B	Inverter On	Status Light
C	In Sync	Status Light
D	Precharge	Status Light
E	Battery Operation	Status Light
F	Low Battery Voltage	Status Light
G	Negative to Ground	Status Light
H	Positive to Ground	Status Light
J	Low Inverter Output Voltage	Status Light
K	High Inverter Output Voltage	Status Light
L	Inverter Off Frequency	Status Light
M	Bypass Source Breaker Closed	Status Light
N	Normal and Inverter Power	Status Light
P	Battery and Inverter Power	Status Light
Q	Bypass Source Power	Status Light
R	Load on Inverter Abnormal	Status Light
S	Load on Bypass Abnormal	Status Light
P18	Normal Inverter Position	Status Light
P19	Bypass Source Position	Status Light
X	Fan Failure	Status Light
V	Inverter Supplying Load	Status Light
W	Bypass Source Supplying Load	Status Light
S1	Manual Bypass Switch	Switch
S2	OFF, A-B, B-C, C-A	Switch
S3	OFF, A-B, B-C, C-A	Switch
Y	Precharge	Switch
S5	OFF, A, B, C	Switch
Z	Transfer / Retransfer Switch 1 (Left) Inverter to Load 2 (Right) Bypass Source to Load	Switch
B1	Battery Input	Circuit Breaker
B4	Bypass Source AC Input	Circuit Breaker
CTR1	(0 - 9999)	Counter

Figure 22 and 23 UPS Battery Charger Section Front Panel and UPS Battery Charger Control Panel



UPS Battery Charger Section Front Panel

A301	DC Output	DC Ammeter
V301	DC Output	DC Voltmeter
B301	AC Input	Circuit Breaker
P301	AC Input Breaker Closed	Status Light
P302	AC Power Failure	Status Light
R301	(Float)	Potentiometer
R302	(Equalize)	Potentiometer
S301	Float (Bottom) / Equalize (Top)	Switch

Figure 22 and 23 UPS Battery Charger Section Front Panel and UPS Battery Charger Control Panel

UPS Controls

The UPS has the following operating devices: (Refer to Figures 22 and 23.)

- Manual Bypass Switch (MBS). This manual switch is used on start-up and shut-down and to perform some UPS maintenance functions. When the UPS MBS is in the BYPASS SOURCE TO LOAD position the UPS static transfer switch is bypassed. Normal operating position is NORMAL INVERTER..
- Battery Precharge Position (Y) - This pushbutton is used at start-up only to charge the UPS filter capacitors slowly before main power is applied.
- Battery recharging controls:
  a) S301 is a two-position switch: Float and Equalize. Float is the normal operating position. In this position, the battery charger maintains a small "trickle" charge on the batteries. EQUALIZE is utilized only by Maintenance/E & I to rapidly recharge the batteries. This switch should never be left in the EQUALIZE position for a long period of time.
  b) R301 and R302 are adjusting controls utilized by E & I when originally setting up the UPS. These should not be adjusted by Operations. These controls adjust the voltage level of the output from the battery charger.
- Inverter Bypass to load key selector switch (Z). - This control switch will switch the position of the static transfer switch. Normal position is the INVERTER TO LOAD position. If the key switch is placed in the clockwise position, the static transfer switch will switch the loads from the inverter to the bypass source. Once in this position, the static transfer switch cannot return to the INVERTER TO LOAD position unless the key selector switch is moved manually counter-clockwise to the INVERTER TO LOAD position.
- Panel Circuit Breakers
  c) B1 is the battery incoming breaker.
  d) B4 is the bypass source incoming breakers.
  e) B301 is the normal AC source incoming breaker.

Uninterruptable Power Supply (UPS) Instrumentation

The Uninterruptable Power Supply (UPS) has two primary control panels that have many instruments and pilot lights that are essential to the proper operation of the UPS. The first control panel is on the face of the UPS battery charger unit (see Figure 24, *UPS Battery Charger Control Panel*). The second panel is mounted on the face of the UPS inverter (see Figures 25, *UPS Inverter Output Instruments Panel* and 26, *UPS Inverter Output Instruments Panel*). These indications are used for early detection of a UPS abnormal condition. Following is a brief discussion of the instruments and pilot lights found on the face of the UPS battery charger cover panel:

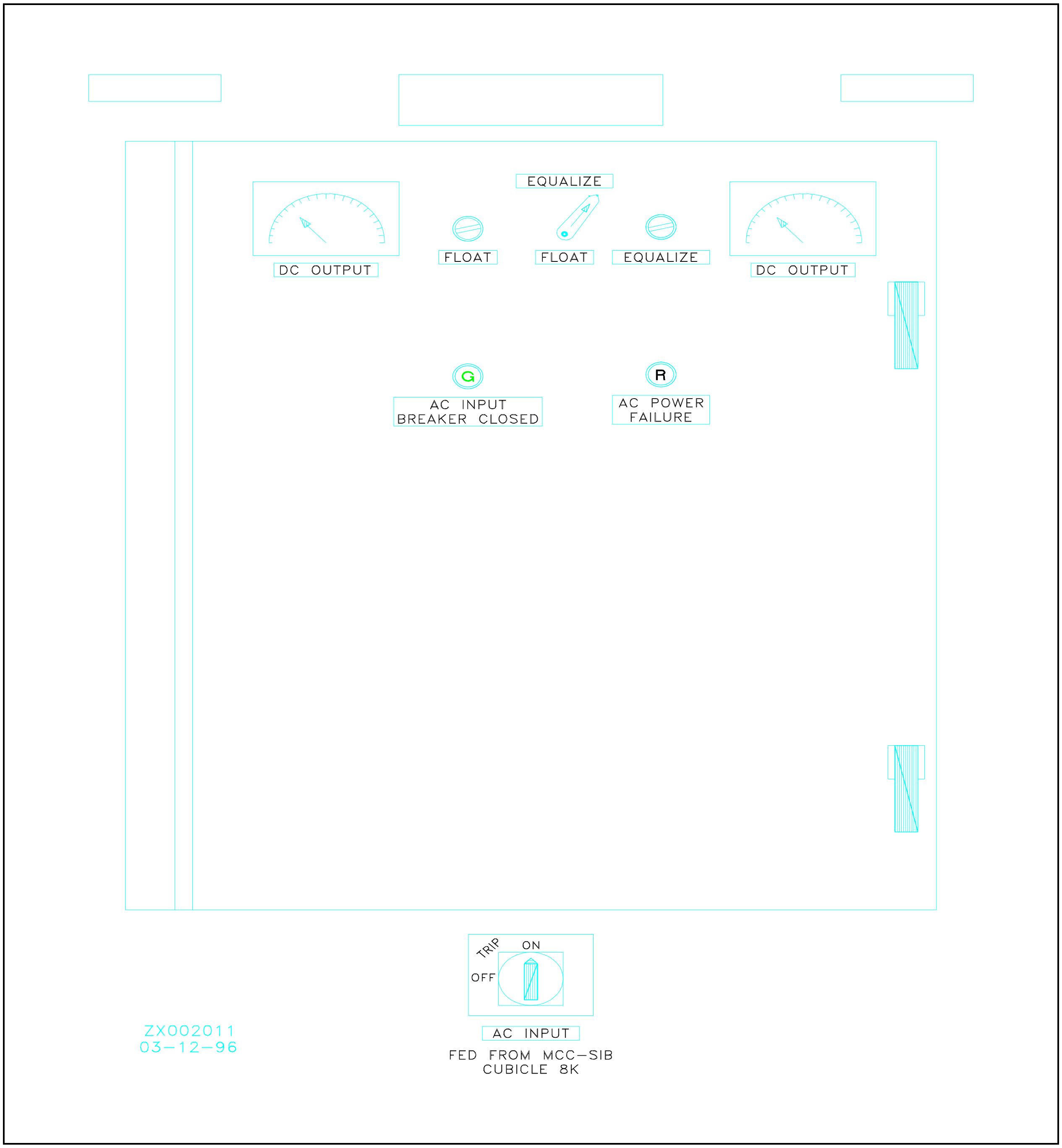


Figure 24 UPS Battery Charger Control Panel

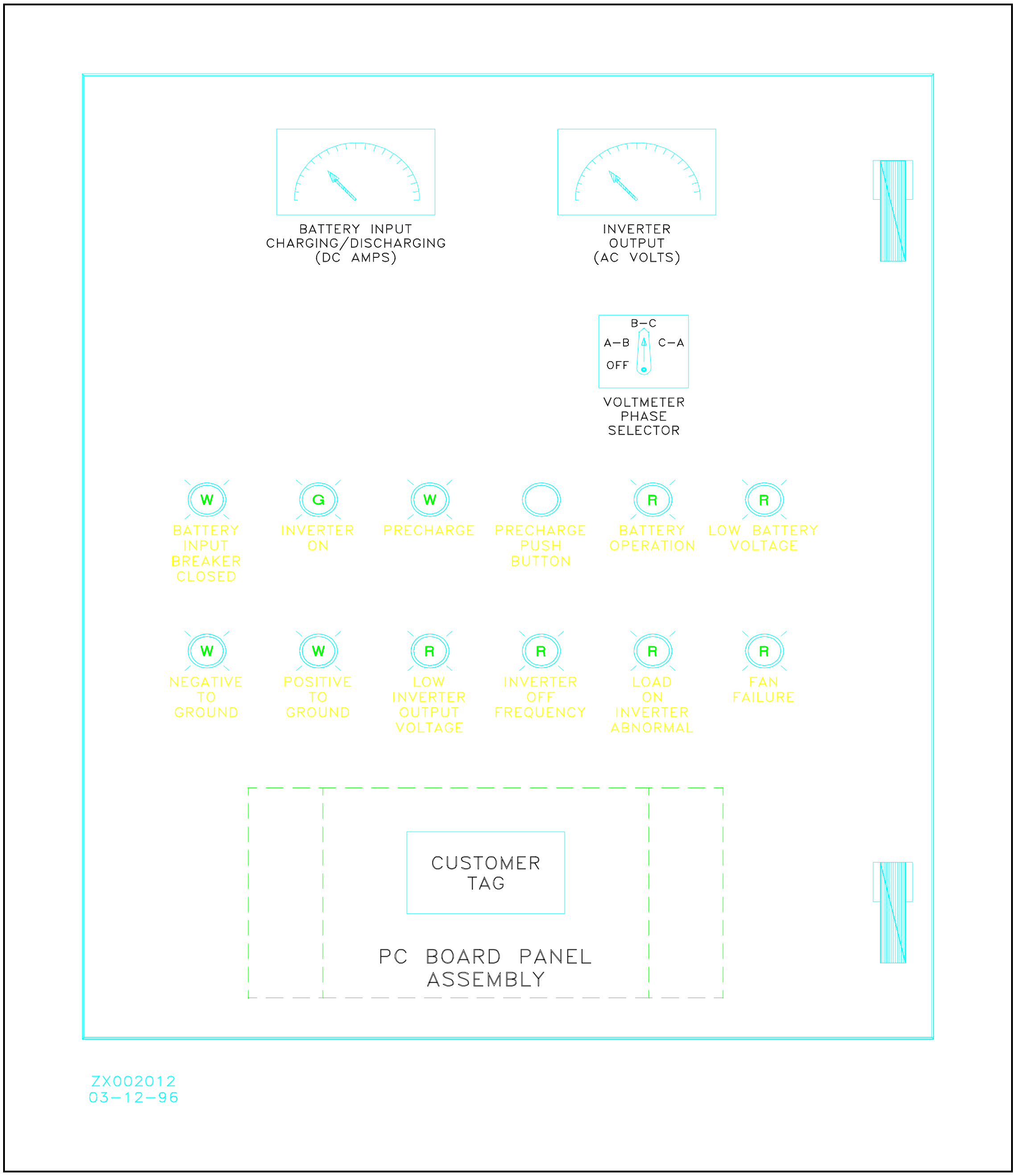


Figure 25 UPS Inverter Output Instruments Panel

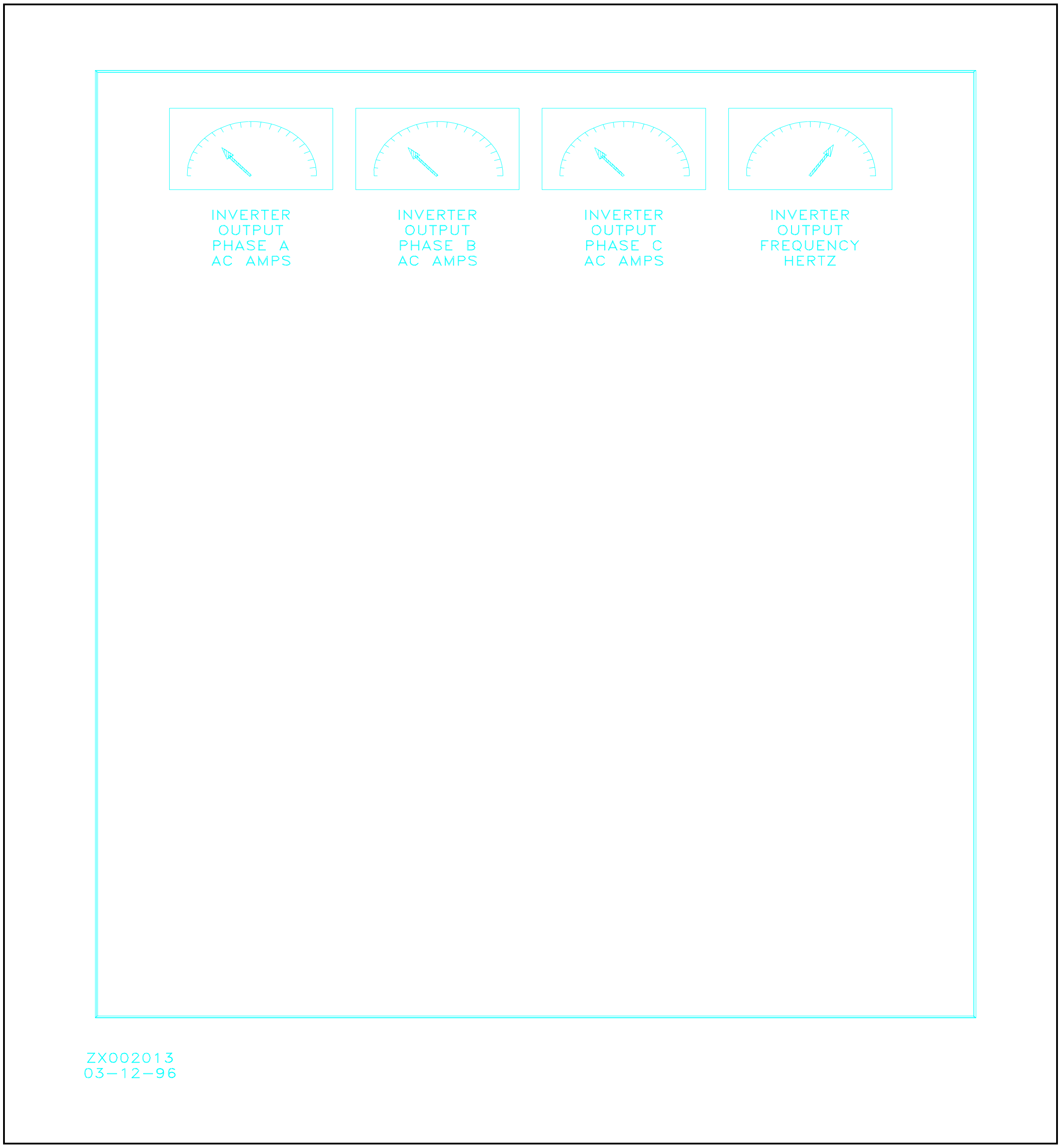


Figure 26 UPS Inverter Output Instruments Panel

DC OUTPUT Ammeter (A301)

The DC OUTPUT ammeter provides indication of the UPS battery charger DC amps output (see Figure 24). The DC OUTPUT ammeter has a range of 0.0 amps to 400 amps. The rated DC output in amps for the UPS battery charger is 160 amps (load amps only). During normal operation of the UPS, the DC OUTPUT ammeter indication varies according to load.

After a condition where the UPS battery bank was used to supply the DCS/PLC power panels, the amperage reading could read higher than 160 amps until the battery bank was able to recharge.

DC OUTPUT Voltmeter (V301)

The DC OUTPUT voltmeter provides indication of the UPS battery charger and battery bank DC volts output (see Figure 24). The DC voltmeter has a range of 0.0 VDC to 300 VDC. During normal operation of the UPS, the DC output range in volts for the UPS battery charger is approximately 275 VDC.

AC INPUT BREAKER CLOSED Pilot Light (P301)

The AC INPUT BREAKER CLOSED pilot light provides indication that the normal AC input supply to the UPS from MCC 7 breaker is closed (see Figure 24).

A green pilot light will illuminate when this breaker is placed in the ON position. The AC input breaker is located on the bottom of the UPS battery charger control panel.

AC POWER FAILURE Pilot Light (P302)

A red AC POWER FAILURE pilot light will illuminate if the normal AC power supply from MCC 7 fails. MCC 7 is the normal 480-VAC power supply to the UPS. If MCC 7 loses power, the UPS will supply the emergency power panels from the battery bank until the standby diesel generator can start and load.

The second control panel that has instruments and pilot lights used to monitor proper operation of the UPS is the UPS inverter control panel (see Figure 25 and 26). For ease of discussion the UPS inverter control panel has been divided into two smaller figures.

BATTERY INPUT CHARGING/DISCHARGING DC Ammeter (A7)

(See Figure 25)

The BATTERY INPUT CHARGING/DISCHARGING DC ammeter provides indication of the status of the Battery Charging System. The DC ammeter will indicate the amount of DC current going to, or from, the battery bank. The DC ammeter has a range of -400 amps to +400.

INVERTER OUTPUT A-Phase AC Ammeter (A1) (Figure 26)

The INVERTER OUTPUT A-phase AC ammeter provides a measurement of the inverter A-phase output current going to the critical load (the DCS/PLC power panels). The range of the INVERTER OUTPUT A-phase AC ammeter is 0.0 amps to 200 AC amps. This ammeter has an adjustable red pointer that is set at 150 amps.

INVERTER OUTPUT B-Phase AC Ammeter (A2) (Figure 26)

The INVERTER OUTPUT B-phase AC ammeter provides a measurement of the inverter B-phase output current going to the critical load (the DCS/PLC power panels). The range of the INVERTER OUTPUT B-phase AC ammeter is 0.0 AC amps to 200 AC amps. Red pointer set at 150 amps.

INVERTER OUTPUT C-Phase AC Ammeter (A3) (Figure 26)

The INVERTER OUTPUT C-phase AC ammeter provides a measurement of the inverter C-phase output current going to the critical load (the DCS/PLC power panels). The range of the INVERTER OUTPUT C phase AC ammeter is 0.0 AC amps to 200 AC amps. Red pointer set at 150 amps.

INVERTER OUTPUT AC Voltmeter (V1) (Figure 25)

The INVERTER OUTPUT AC voltmeter provides a measurement of the phase-to-phase output voltage of the inverter. The AC voltmeter has a range of 0.0 VAC to 300 VAC. The normal reading is 208 VAC.

A four-position, voltmeter phase selector is used to read the AC voltage range of each of the three phases of the inverter. The four positions are OFF, A-B, B-C, and C-A. The OFF position will display no voltage measurement on the voltmeter. The “A-B” position will provide the CIF operator with inverter output AC voltage between phases A and B. The B-C position will provide the CIF operator with inverter output AC voltage between phases B and C. The C-A position will provide the CIF operator with inverter output AC voltage between phases C and A. The voltmeter selector is a cam-operated, rotary-type switch.

INVERTER OUTPUT Frequency Meter (E1) (Figure 26)

The INVERTER OUTPUT frequency meter provides indication of the inverter output frequency. The frequency meter has a range of 58 Hz to 62 Hz. The normal INVERTER OUTPUT frequency range is from 59.7 Hz to 60.3 Hz. The inverter has two frequency alarms below at 59.7 Hz and above 60.3 Hz, but these only gives a UPS TROUBLE alarm on DCS to alert an operator.

BATTERY INPUT BREAKER CLOSED Pilot Light (A) (Figure 25)

The BATTERY INPUT BREAKER CLOSED pilot light provides indication that the BATTERY INPUT breaker located on the bottom of the UPS inverter power panel is in the ON position. The BATTERY INPUT BREAKER CLOSED pilot light is a white indicating light that is illuminated during normal UPS operation.

INVERTER ON Pilot Light (B)

The INVERTER ON pilot light is a green indicating light that provides current status of the UPS MANUAL BYPASS SWITCH. The green pilot light will illuminate when the MANUAL BYPASS SWITCH is in the INVERTER TO LOAD position.

PRECHARGE Pilot Light (D)

A white PRECHARGE pilot light provides indication that the AC to DC output filter capacitors are charged. The output filter capacitors are precharged automatically to prevent the input fuse or circuit breaker from being blown due to heavy surge currents. The PRECHARGE pilot light will remain illuminated after the UPS has been shut down until the output filter capacitors are discharged.

BATTERY OPERATION Pilot Light(E)

A red illuminated BATTERY OPERATION pilot light indicates the DC battery bank is supplying the load to the emergency power panels.

Illumination indicates that normal power to the area has been lost and the DG-002 standby diesel generator has not started or begun to supply load to the area. In addition to the local pilot light indication, the UPS TROUBLE light on the control room DCS panel will activate.

LOW BATTERY VOLTAGE Pilot Light(F)

A red illuminated LOW BATTERY VOLTAGE pilot light indicates that the DC battery charger output has dropped to a level where the batteries are nearing the discharge point. The control room UPS TROUBLE light on the DCS will activate if this condition occurs. The UPS will not transfer to bypass until the DC battery charger output drops five (5) volts below the level at which this pilot light illuminates.

NEGATIVE TO GROUND Pilot Lights (G)

A white NEGATIVE TO GROUND pilot light will illuminate to indicate a DC negative to ground fault on the negative cable from the battery bank. A DC relay coil is connected between the negative bus and ground. Another relay coil is connected to the positive bus. By connecting these relay coils in series, each coil will see one-half of the normal DC bus voltage. For 250 VDC, each coil will see 125 VDC. If the negative bus is grounded, the voltage across the second DC relay coil will raise to 250 VDC, because it is now connected to both sides of the bus, which is sufficient to energize the coil. Contacts from the relay coil close, providing sufficient power to illuminate the pilot light.

The UPS TROUBLE light will activate on the DCS in the control room. The normal response of operations to this condition is to call the UPS maintenance vendor and report the condition for vendor resolution.

POSITIVE TO GROUND Pilot Light (H)

A white POSITIVE TO GROUND pilot light will illuminate to indicate a DC positive to ground fault on the positive cable from the battery bank. A DC relay coil is connected between the positive bus and ground. Another relay coil is connected to the negative bus.

By connecting these relay coils in series, each coil will see one-half of the normal DC bus voltage. For 250 VDC, each coil will see 125 VDC. If the positive bus is grounded, the voltage across the second DC relay coil will rise to 250 VDC, because it is now connected to both sides of the bus, which is sufficient to energize the coil. Contacts from the relay coil close, providing sufficient power to illuminate the pilot light

The UPS TROUBLE light will activate on the DCS panel in the Control Room. The normal response of operations to this condition is to call the UPS maintenance vendor and report the condition for vendor resolution.

LOW INVERTER OUTPUT VOLTAGE Pilot Light (J)

A red LOW INVERTER OUTPUT VOLTAGE pilot light will illuminate if the inverter output voltage drops below 108 VAC. The UPS TROUBLE light will activate in the control room. The UPS will automatically transfer to the bypass source (MCC 8, cubicle 6J) to supply the emergency power panels if this condition occurs.

INVERTER OFF FREQUENCY Pilot Light

The red INVERTER OFF FREQUENCY pilot light will illuminate if the INVERTER OUTPUT frequency meter drops below 59.7 Hz or rises above 60.3 Hz. The control room UPS TROUBLE light will activate if this condition arises. This condition may require a manual operator shutdown of the emergency loads, this is not automatic.

LOAD ON INVERTER ABNORMAL Pilot Light (R)

A red LOAD ON INVERTER ABNORMAL pilot light will illuminate if the load on the inverter has exceeded the UPS power rating. A sensing device reads the amperage in each of the three output phases from the inverter. The static transfer switch will transfer to bypass if any phase exceeds 120% of full load rating of the inverter.

The UPS TROUBLE light on the control room DCS panel will illuminate if an abnormal current condition should arise.

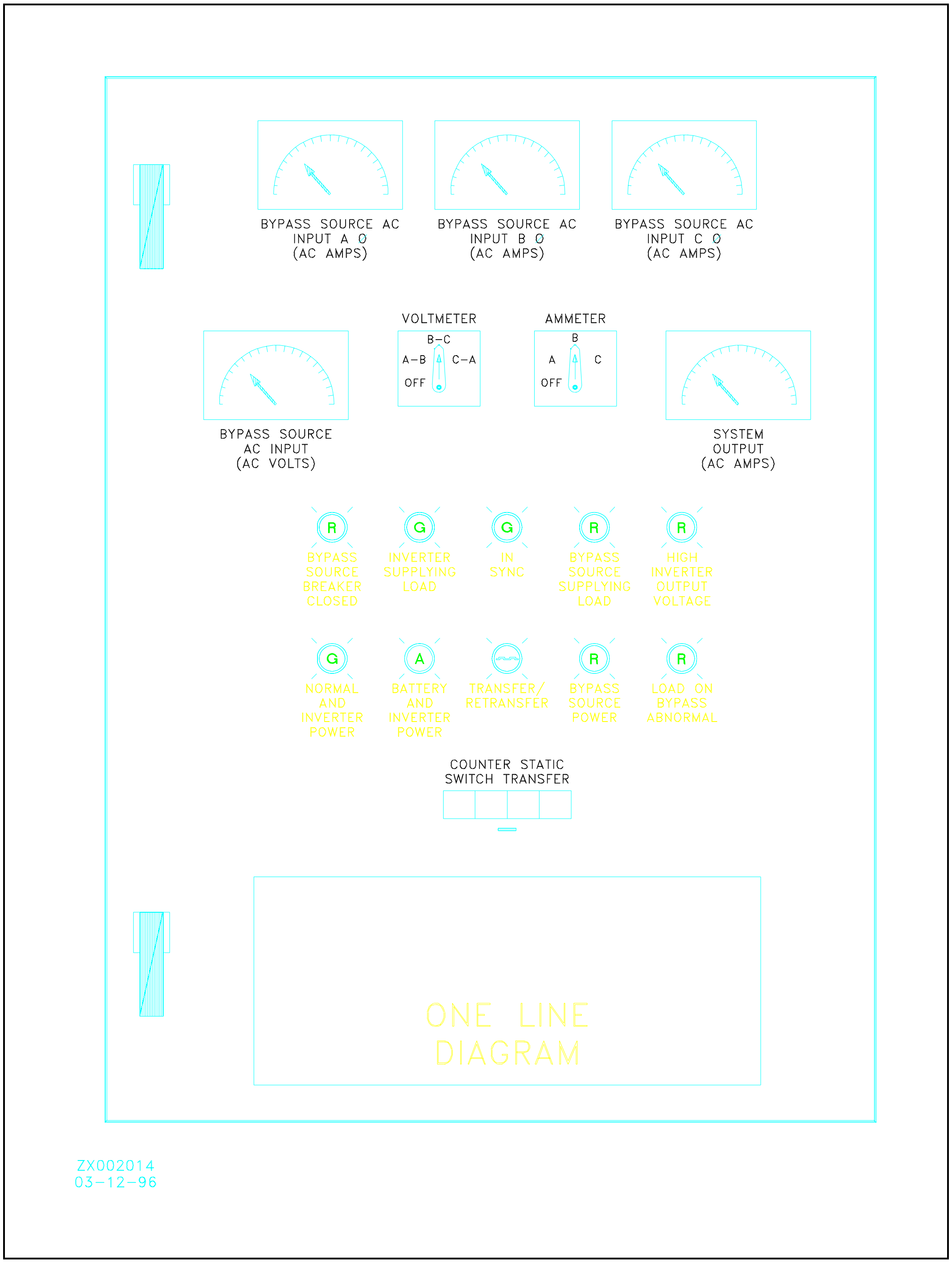


Figure 27 CIF UPS Inverter Bypass Source Instrument Panel

The UPS will automatically transfer to the bypass source (MCC 8, cubicle 6J) to supply the emergency power panels should this condition arise.

FAN FAILURE Pilot Light (X)

A red FAN FAILURE pilot light will illuminate if one of the UPS equipment cooling fans fails. This condition could cause eventual failure of some of the UPS internal components. The control room UPS TROUBLE light on the DCS panel will illuminate if this condition arises. A fan failure will not cause the UPS to transfer to bypass power.

Figure 27, *UPS Inverter Bypass Source Instruments Panel*, illustrates the UPS inverter bypass source instruments and pilot lights section found on the UPS inverter control panel.

A brief description of the instruments and pilot lights found on the UPS inverter bypass source section of the UPS inverter control panel follows.

BYPASS SOURCE A Phase AC Ammeter (A4)

The BYPASS SOURCE A-phase AC ammeter provides indication of the bypass source A-phase output current. The range of the BYPASS SOURCE output A-phase AC ammeter is 0.0 amps to 200 AC amps. This ammeter has an adjustable red pointer. Full load output is 138 amps, and the pointer is typically set at 150 amps.

BYPASS Source B Phase AC Ammeter (A5)

The BYPASS SOURCE B-phase AC ammeter provides indication of the bypass source B phase output current. The range of the BYPASS SOURCE B-phase AC ammeter is 0.0 AC amps to 200 AC amps. This ammeter has adjustable red pointer set at 150 amps.

BYPASS SOURCE C Phase AC Ammeter (A6)

The BYPASS SOURCE C-phase AC ammeter provides indication of the bypass source C-phase output current. The range of the BYPASS SOURCE C phase AC ammeter is 0.0 AC amps to 200 AC amps. This ammeter has adjustable red pointer set at 150 amps.

BYPASS SOURCE AC INPUT Voltmeter (V2)

THE BYPASS SOURCE AC INPUT voltmeter provides indication of the incoming voltage from the bypass source transformer. The range of the BYPASS SOURCE AC input voltmeter is 0.0 VAC to 300 VAC. Normal bypass source AC input is 208 VAC. An adjacent instrument transfer switch (S2) permits monitoring voltages throughout the three (3) phases.

SYSTEM OUTPUT AC Ammeter (A8)

The SYSTEM OUTPUT AC ammeter provides indication of the AC output to the DCS and PLC power panels. The range of the SYSTEM OUTPUT AC AMMETER is 0.0 AC amps to 200 AC amps.

A four-position ammeter selector switch (S5) is used to monitor the AC amperage between two phases of each of the bypass sources three (3) output phases. The four positions are: OFF, A-B, B-C, and C-A. The ammeter selector functions in the same manner as the voltmeter selector switch described above. The ammeter selector is a cam-operated, rotary-type switch.

BYPASS SOURCE BREAKER CLOSED Pilot Light (M)

A red BYPASS SOURCE BREAKER CLOSED pilot light will illuminate if the BYPASS SOURCE AC INPUT breaker is placed in ON position. This provides the operator with indication that bypass power is available to the UPS if needed.

INVERTER SUPPLYING LOAD Pilot light (V)

A green, illuminated INVERTER SUPPLYING LOAD pilot light provides indication that the UPS inverter is supply 120/208 VAC power to the emergency power panels.

IN SYNC Pilot Light

A green, illuminated IN SYNC pilot light provides the operator with indication that the UPS inverter AC output and the bypass AC input are within synchronization. The UPS cannot transfer from normal to bypass, or from bypass to normal, if the phase difference or voltage between the UPS inverter AC output and the bypass AC input are not within tolerance (sync).

BYPASS SOURCE SUPPLYING LOAD Pilot Light (W)

A red, illuminated BYPASS SOURCE SUPPLYING LOAD pilot light provides indication that the UPS has transferred the AC supply to the power panels from the UPS inverter to the bypass source. The static transfer switch will sense a loss of normal power from the UPS inverter and automatically switch to the bypass source.

The UPS TROUBLE light will activate on the control room DCS panel if the static transfer switch transfers the UPS to the bypass source. If the condition that caused the static transfer switch to transfer to the bypass source is cleared, the static transfer switch will retransfer the load automatically back to the UPS-inverter.

HIGH INVERTER OUTPUT VOLTAGE Pilot Light (K)

A red HIGH INVERTER OUTPUT VOLTAGE pilot light will illuminate if the inverter output phase to ground voltage rises above 132 VAC of rated output (10% of 120 VAC).

A sensing device monitors all three phases of the inverter output amperage for this condition. UPS TROUBLE light will activate on the control room DCS panel if this condition arises. The UPS will automatically transfer to the bypass source (MCC 8, cubicle 6J) to supply the emergency power panels at this time.

NORMAL AND INVERTER POWER Pilot Light (N)

A green NORMAL AND INVERTER POWER pilot light is illuminated when the UPS inverter is supplying emergency power panels with critical power. This pilot light indicates that the UPS is in normal operation.

BATTERY AND INVERTER POWER Pilot Light (P)

An amber BATTERY AND INVERTER POWER pilot light provides indication that the UPS battery bank is supplying the UPS inverter with DC power. The amber pilot light will illuminate when the UPS senses a loss of normal power and switches over to the battery bank. The battery bank is designed to supply power to the critical loads for 15 minutes.

BYPASS SOURCE POWER Pilot Light (Q)

A red illuminated BYPASS SOURCE POWER pilot light provides indication that the bypass power source fails. This means that a failure in the UPS will de-energize the DCS, because bypass power is not available.

LOAD ON BYPASS ABNORMAL Pilot Light (S)

A red illuminated LOAD ON BYPASS ABNORMAL pilot light provides indication that the bypass power source has an abnormal current condition. A sensing device monitors the amperage on each of the three phases of bypass current power. If the amperage of any of the three phases rises above 120% of normal bypass current, the UPS TROUBLE light on the control room DCS panel will activate.

The MANUAL BYPASS switch has two pilot lights that give the current position status of the MANUAL BYPASS switch (refer to Figure 22). A brief description of these pilot lights follows.

NORMAL INVERTER POSITION Pilot Light (P18)

A green, illuminated NORMAL INVERTER POSITION pilot light provides indication that the MANUAL BYPASS switch on the UPS inverter is in the INVERTER TO LOAD position This is the normal operation position of this switch for the UPS.

BYPASS SOURCE POSITION Pilot Light (P19)

A red, illuminated BYPASS SOURCE POSITION pilot light provides indication that the MANUAL BYPASS SWITCH on the UPS inverter is in the BYPASS SOURCE TO LOAD position.

STATIC SWITCH TRANSFER COUNTER (CTR1)

The STATIC SWITCH TRANSFER COUNTER provides indication of the cumulative number of times the switch has been switched from the INVERTER TO LOAD position to the BYPASS SOURCE TO LOAD position and back again. The counter is a four-digit, mechanical-type that can be reset to zero by depressing the reset pushbutton located on the bottom of the counter.

Whenever any trouble light is energized at the UPS panel, a UPS TROUBLE signal is sent to the DCS. This signal for the UPS-YA-5409 is labeled 5408EA.

VS Drive

The caustic VS drives have the following controls and instrumentation:

- ON-OFF Switch - Switch at top of panel turns AC power to the VS drive on or off.
- SPEED CONTROL DIAL (Zero to 10)-Controls the output speed of the VS drives manually. Zero position is zero speed, and 10 position is full speed. Speed dial is used if running in the MANUAL mode.
- AUTO-MANUAL SWITCH-When in the AUTO position, speed can be controlled from a remote location. In MANUAL, speed is controlled with the speed control dial. NORMAL position is AUTO.
- RUN-JOG SWITCH-When in Jog drive is energized at low speed only momentarily. Normal position is RUN. In the RUN position, the motor will continuously run at the speed determined by the speed dial, or by the AUTO position speed signal. RUN is the normal position.
- START-STOP SWITCH-Controls the output from the drive to the motor. In the STOP position, the motor cannot be driven. START is the normal position for this switch.

Safety Switches

Safety switches are manually operated. When the Safety Switch handle is in the UP (or sticking out in front of the panel) the Safety Switch is ON. When the Safety Switch is in the DOWN position, the Safety Switch is OFF. Safety switches have no instrumentation.

Power Transformers

480-VAC to 120/208-VAC transformers have no controls and no instrumentation. These transformers are energized/de-energized from a motor control center cubicle. In an emergency, the safety switch mounted immediately ahead of the transformer can be used to de-energize these transformers (check CIF Management for details).

Panel boards

Panel boards contain many small circuit breakers similar to those found in residential houses. Panel boards typically have no instrumentation. The breakers are controlled by manually activating the breaker handle. Should an electrical fault (problem) occur, the breaker handle will move from the ON position to a point mid way between ON and OFF. To reset the breaker, the handle is moved to OFF and then back to ON. H-Area policy permits the operator to reset a panel board (120 VAC only) breaker one time if the cause of the trip is understood and corrected before re-setting.

Summary

- The most common electrical instrument used are ammeters, voltmeters, wattmeters and frequency meters. Some instruments are arranged to alarm if the parameter being monitored is outside of acceptable limits.

- Controls can vary from being simple ON-OFF actuators to elaborate controls. Simple mechanical ON-OFF devices are found at the switchgear breakers, MCC cubicles, panel boards, VS drives, safety switches and UPS panels.

- Automatic controls are found at the ATSs, SDGs, and UPS.

- Elaborate control schemes are normal for motors driven by MCC compartment devices and 480-VAC panels. These schemes could involve the DCS as well as local controls.

SYSTEM INTERRELATIONS

This section covers the most common electrical symbols that will be found on schematic diagrams. This section covers the two basic motor control circuits, LVP and LVR, upon which all other, more complex, circuits are built. The purpose of this section is to show how standard circuits function by using schematic diagrams. By understanding basic schematics, trainees will develop an understanding of how the Electrical Distribution System interfaces with system sensors and with the DCS.

5.01 IDENTIFY the electrical schematic symbols for the following motor controller components:

a. Contactor or starter electromagnetic coil

b. Selector switches

c Controller START and STOP push buttons and lights

d. Main, Auxiliary and interlocking contacts.

e. Transformers

f. Overload relay and contacts

g. System contacts that interface with controllers

h. MC plug-ins compartments

1. MCC switch and fuses

5.02 Given an electrical schematic, IDENTIFY the circuit components and DETERMINE their electrical ratings

5.03 EXPLAIN the operation of low voltage release (LVR) and low voltage protection (LVP circuits.

5.04 Given a schematic diagram, ANALYZE circuit operation and CLASSIFY the circuit as either a low voltage protection (LVP) circuit or a low voltage release (LVR) circuit.

5.05 Given a controllers schematic diagram, EXPLAIN how interlocks from other area devices, panels, or controllers can be arranged in the controller circuit to either permit or prevent the controller from being started.

5.06 DESCRIBE ways in which the CIF-Area Electrical Distribution System communicates its status to local operating stations, to control room consoles, and to a high level control system (programmable logic controller or digital control system).

Electrical Distribution System Schematic Drawing Symbols

Refer to Figure 28, *CIF Schematic Diagram Symbols*. The following symbols are typically found on CIF schematic diagrams:

1. <u>Coil</u>- may be either a jagged line (SRS standard) or a circle with an "M" inside. For main contactors in motor controllers or starters, this coil is often referred to as the M coil.
2. <u>HAND/OFF/AUTO selector switch</u> - may take the form of a circle with the letters "HS" inside, or a three-position switch showing the electrical connections for each position, or a switch with three arrows showing the positions. If an arrowed switch is shown, when the switch is in the HAND position, the top contact is closed and the button contact is open (the Xs and Os act as a legend to show this). For the top contact, when the switch is in the HAND position, the X means that the contact is closed. In the OFF position, both the top and bottom contacts are open as shown by the "Os." When in the AUTO position, the top contact is open and shows an "O", and the bottom contact is closed and shows an "X".
3. <u>Time delay relay contacts</u> - may be shown either as contacts with a legend or as a switch with arrows. Their are two types of time delay relays. One type of relay is time-delayed on (delayed actuation after energization). Relay contacts of this type are referred to as "Timed Closing After Energizing" (TCAE) or "Timed Opening After Energizing" (TOAE) relays. The other type of relay is timed-delayed off (delayed actuation after de-energizing (TCAD) relays.

- When the time delay relay coil is energized, the contact does not immediately close, but is delayed until the relay times out, and then the TCAE contact closes. When power is removed from the coil, the time delay contact TCAE immediately opens. This is illustrated by the arrow on the switch showing the direction in which the contact moves once the timer has timed out.

4. When the time delay relay coil is energized, the contact TOAD immediately closes. When the time delay relay is de-energized, power is removed from the coil, the TOAD contact does not immediately open, but is delayed in accordance with the time set on the relay. After the relay "times out," the TOAD contact opens. This is illustrated by the arrows on the switch showing the direction in which the contact moves once the timer has timed out.
5. When the time delay relay coil is energized, the contact will not immediately open. After the time delay, the contact will open. Once the relay is de-energized, the contact will immediately re-close.
6. When the time delay relay coil is energized, the contact immediately opens. When the time delay relay is de-energized, the TCAD contact does not immediately close, but is delayed by the relay's time delay. After the relay "times out," the TCAD contact closes.

7.&8. Will be demonstrated in class.

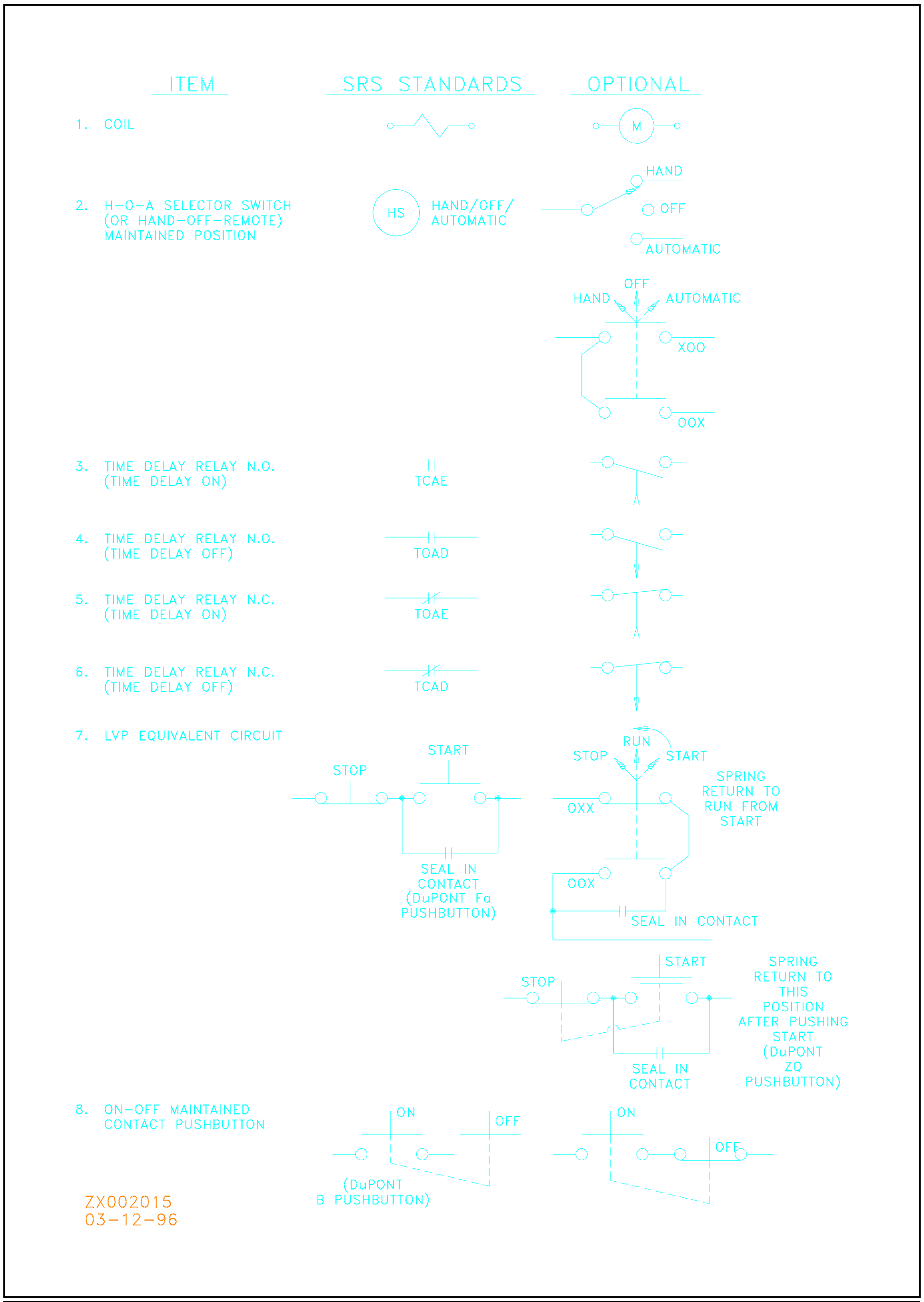


Figure 28 Schematic Diagram Symbols

PLC Schematic Legend

Refer to Figure 29, *CIF PLC Schematic Legend*. These symbols are all used in various schematics for the CIF processes.
Multiplexing Panels (MUX panels or I/O panels, or drops) contain devices that accept signals from electrical equipment or process-mounted devices such as level switches or flow transmitters. I/O panels then convert these signals to information usable by the main DCS or main processors. In a similar manner, DCS or PLC main processors can send signals to the electrical equipment or the process-mounted devices via the I/O panels. In many cases, the DCS or PLC monitors safety parameters and (through the I/O) sends “enable” or “disable” signals to control circuits in motor starters or VSDs. These interlocks prevent operation of the equipment unless system safety requirements are satisfied. Additional information about I/O panels can be found in the DCS and the PLC System Descriptions.

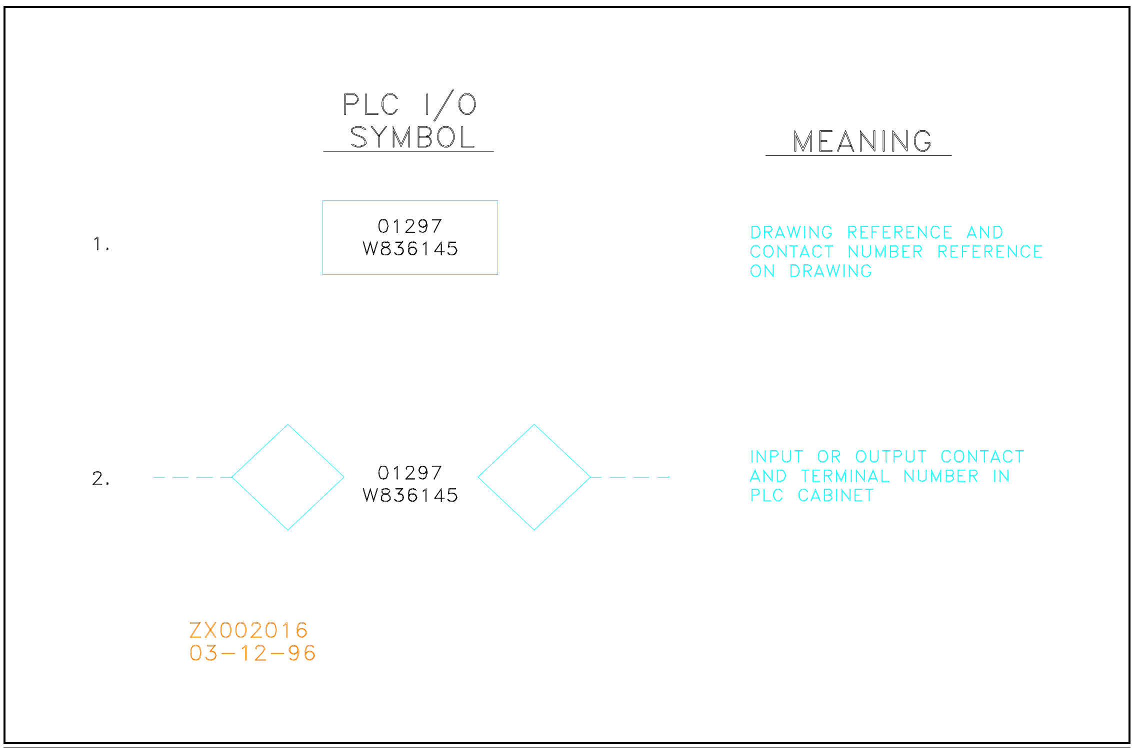


Figure 29 PLC Schematic Legend

Low Voltage Protection and Low voltage Release Circuits Introduction

The main purpose of this section of the study guide and classroom lecture is to familiarize the student with typical electrical schematic diagrams and to discuss how electrical equipment works. By becoming familiar with several basic control schemes, a student will be able to apply this knowledge to all types of controls. Schematic diagrams will be the primary source of information for the student. Schematic diagrams not only show the basic control circuitry for a particular motor or drive, but also show the location of operating devices and interlocking controls.

Although there are hundreds of different electrical schematic diagrams used for the process, there are only two (2) basic schematics of interest to an operator. These two (2) circuits are referred to in the electrical industry as low voltage release (LVR) and low voltage protection (LVP). These circuits have been in existence for decades and will be the basis upon which other circuits are built.

Low Voltage Protection (LVP) Circuits

Low voltage protection (LVP) circuits have the characteristic that if they lose supply power, the associated load will stop. When power is restored, the load will not restart automatically. These circuits are used when it is desirable to:

- Prevent a process from restarting automatically, which results in an uncontrolled restart of operation.
- Prevent large loads or multiple small loads from restarting when power is restored. The large starting surge from all the loads restarting simultaneously could jeopardize the restored power or overload the motor control center or substation or, restoring power from a standby diesel generator could overload the SDG.

Simple LVP Circuits

Figure 30, *Basic LVP Schematic* illustrates a simple schematic diagram of a 3-pole contactor. The M contacts are the main contacts and are used to apply power to the load. The M contacts are opened and closed using the M coil, and are normally open (NO) when the coil is de-energized. Contact M_A is an auxiliary contact which is mounted on the main contactor chassis. M_A is also a NO contact and is closed whenever the M coil is energized.

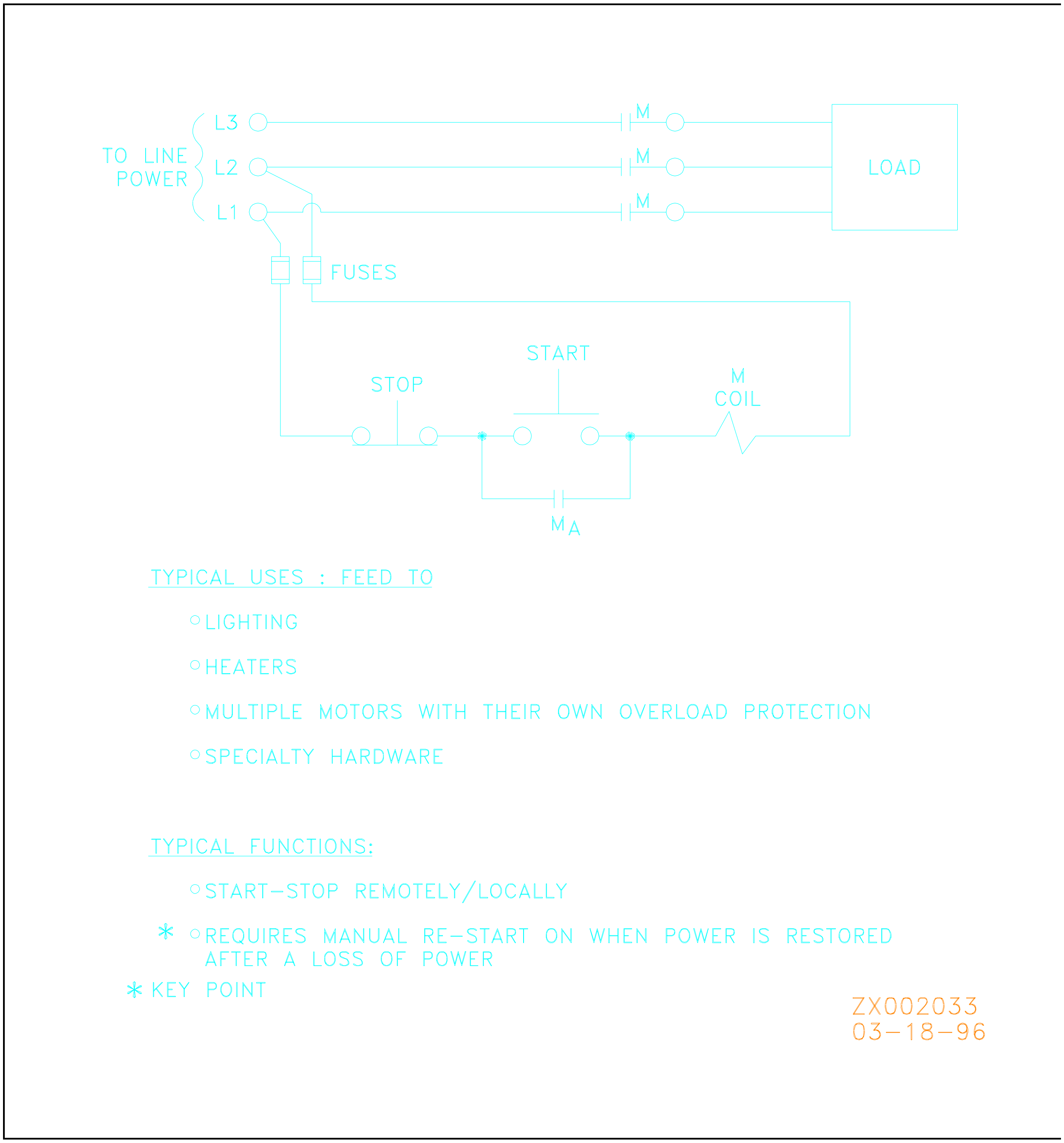


Figure 30 Basic Contactor LVP Simplified Schematic

The pushbuttons shown for STOP and START are momentary contacts. This means that if the START pushbutton is pushed to close the main M contacts, the pushbutton will spring return to the open position when released. Likewise, the STOP pushbutton, normally closed, will open when pressed and spring return to closed when released.

Assume that 480-VAC, three-phase, 60-Hz power is applied to line power terminals L1, L2 and L3. Power cannot flow to the motor until the M contacts close. When the START pushbutton is pressed, control power to the M main coil flows from L1, through one control power fuse, through the STOP pushbutton contact, through the START pushbutton contact (which is being pushed down) and the M coil, and back to L2 through the other control power fuse. Since current is flowing through the M coil, the M main contacts to the load will close, providing power to the load.

When the M coil is energized M_A also closes, completing a circuit around the START pushbutton. The pushbutton can now be released and the M coil and load will remain energized. Contact M_A is called a “seal-in”, “maintaining,” or “holding” contact.

To stop the load, the STOP pushbutton is pressed, breaking the current flow through the M coil. This will result in the M main contacts in the power supply to the load to open, causing the load to stop. The M_A contact will also open when the M coil is de-energized. Since the M_A contact is open, the current flowpath to re-energize the M coil is no longer present. The STOP pushbutton can be released without the load restarting.

If power is lost, the M coil is also de-energized, stopping the load. The M_A opens, preventing the load from restarting when power returns. Consequently, the load will not restart automatically upon power restoration, and must be restarted by pressing the START pushbutton.

This circuit is referred to as LVP because the load being fed from the M contactor will not automatically restart upon a loss and re-initiation of power. From an operating standpoint, this means that all circuits fed by contactors (or starters) set up for LVP must be re-started every time power is lost. The time it takes the M coil to drop out is a short duration (one cycle). For this reason, all LVP circuits must be re-started even if standby diesel generator power is available (takes approximately 15 seconds to become available).

Simple LVP Controllers With Indicating Lights

An LVP controller may also be equipped with indicating lights which provide indications of the operation of the associated load (refer to Figure 31, *Basic Contactor LVP with Light Schematic*). In this circuit, a green light is placed in parallel around the M coil. When the M coil is energized, the motor starts. The power supplied to the M coil is also applied to a green light. The green light will then be energized any time that the load is running.

Should power be lost to the load, the M coil will drop out, opening M and M_A contacts and turning off the green light. The schematic diagrams have no relationship to where parts are physically located. The main contact M, the coil M and the auxiliary contact (holding contact

M_A) are in fact all parts of the contactor; however, the START and STOP pushbuttons and green light could be mounted anywhere. These devices could be mounted at a desk, at a motor control center, or separately mounted. On schematic drawings, the locations for all devices are typically shown in the schematic legend, or a note is marked beside the device in question.

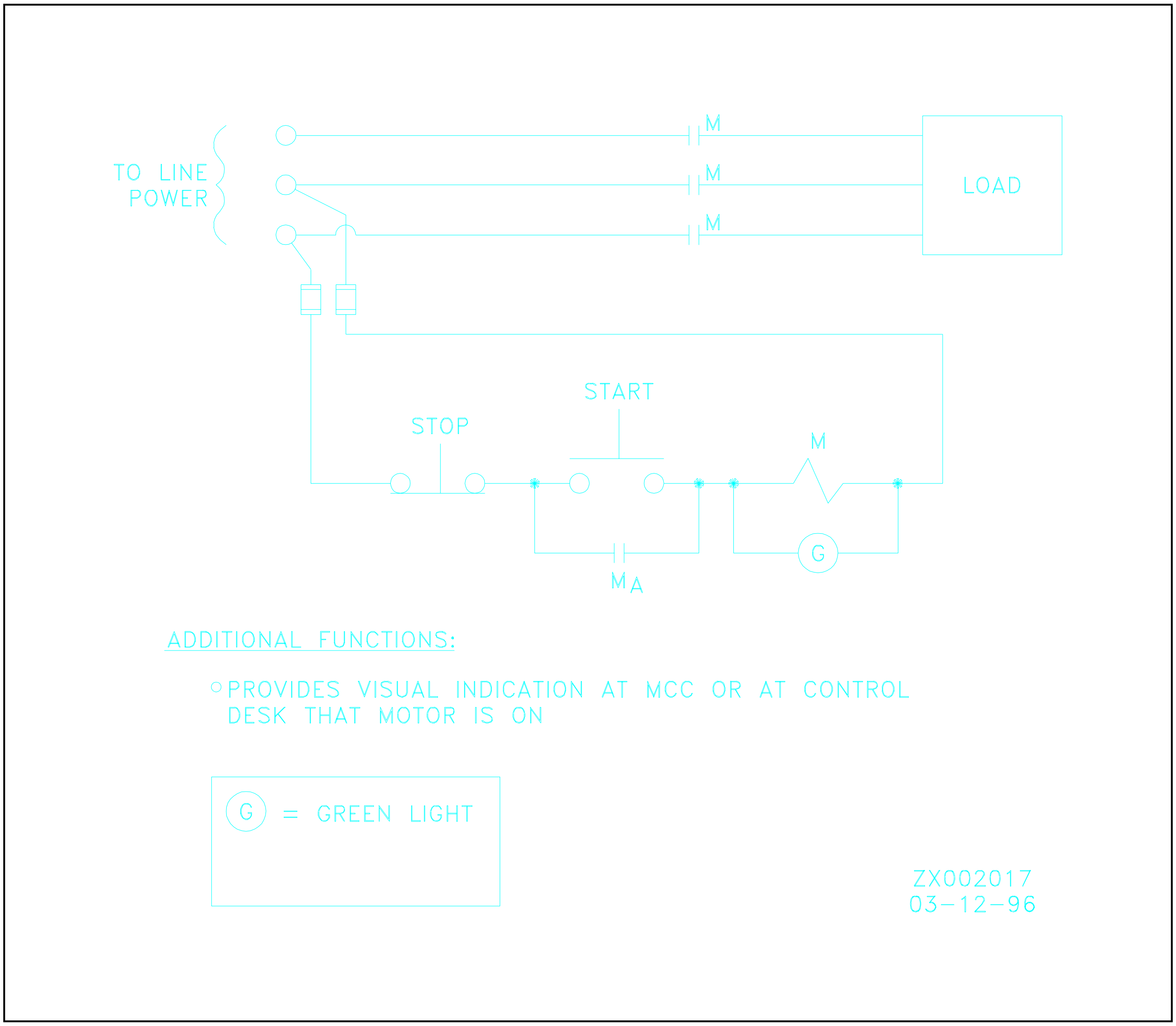


Figure 31 Basic Contactor LVP Simplified Schematic with Run Light

A LVP controller may also be equipped with two lights: a green light, indicating that the load is energized, and a red light, indicating that the load is de-energized (refer to Figure 32, *LVP Schematic with On and Off Lights*).

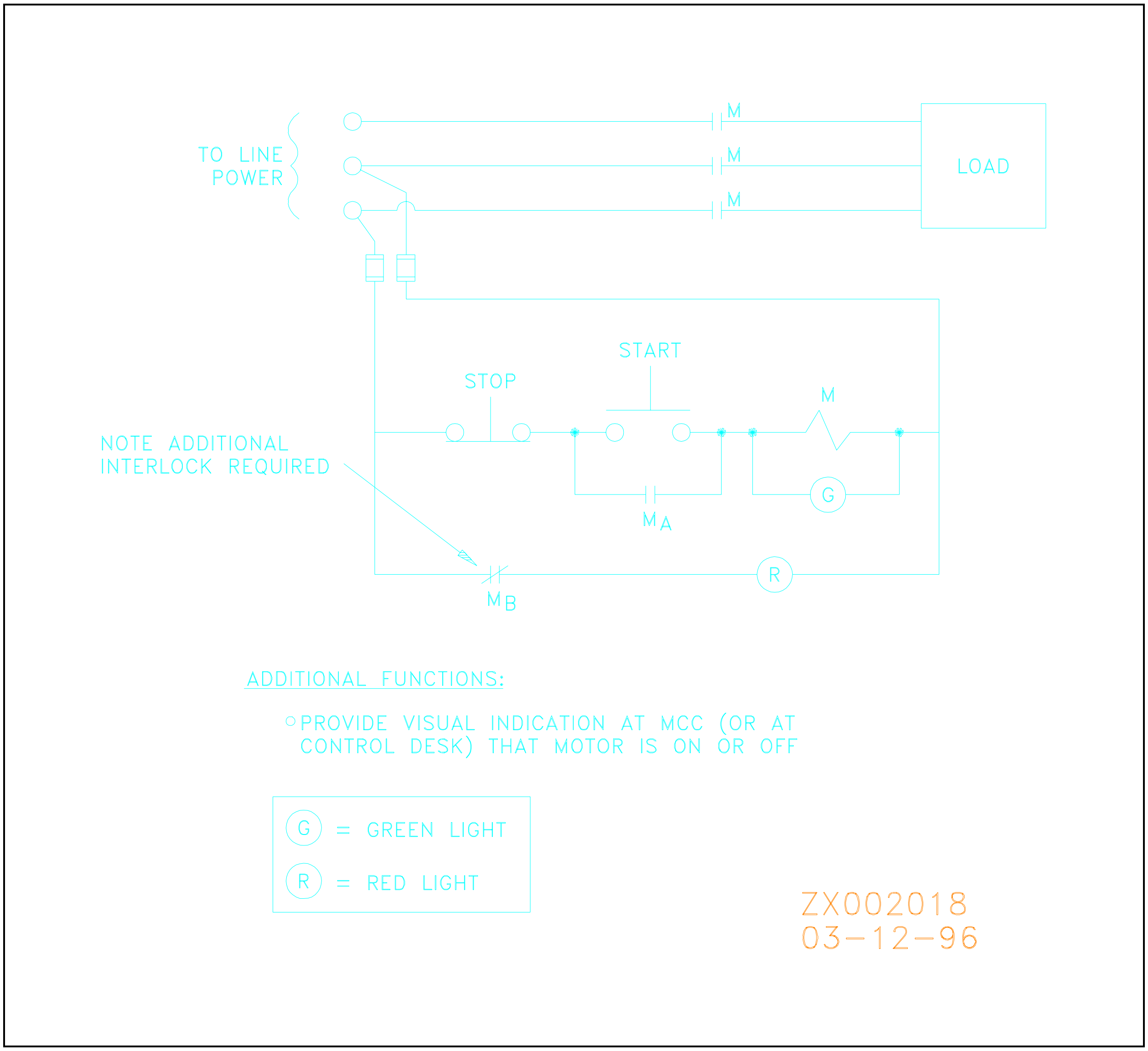


Figure 32 Basic Contactor LVP Simplified Schematic with On and Off Lights

The addition of the red light does not affect the LVP circuit. In this case, the main contactor has two auxiliary contacts: M_A is a normally open (NO) contact which closes when the M coil is energized; M_B is a normally closed (NC) contact which closes when the M coil is de-energized. In this circuit, whenever line power is available and the load is not energized, the M coil is de-energized, causing contact M_B to be closed. The red light is energized using control power through the M_B contact, indicating that the load is not operating.

Whenever the START button is pushed, the M coil is energized, the M_A contact closes, and the M_B contact opens. This closes the main contacts M to feed the load, turns on the green light and turns off the red light.

If the load is energized and the power supply (line power) is lost, the load will stop. In this case, power will not be available for the red light. Consequently, all run and stop indications are lost when power is lost to the controller.

LVP Motor Controllers (Starters)

LVP motor controllers (also referred to as starters) have an addition of overload relays. An overload relay has sensors (heaters), located in the power supply lines to the motor, which heat up as the motor current increases (refer to Figure 33, *Non-Reversing Starter LVP Schematic*). Overload relays on motors are necessary because motors may experience slight overloads (such as mechanical binding of a pump) which may not create enough current to trip the power supply protective devices breaker (overcurrent trips, fuses, etc.). If the motor was allowed to operate during the overload condition, damage may occur.

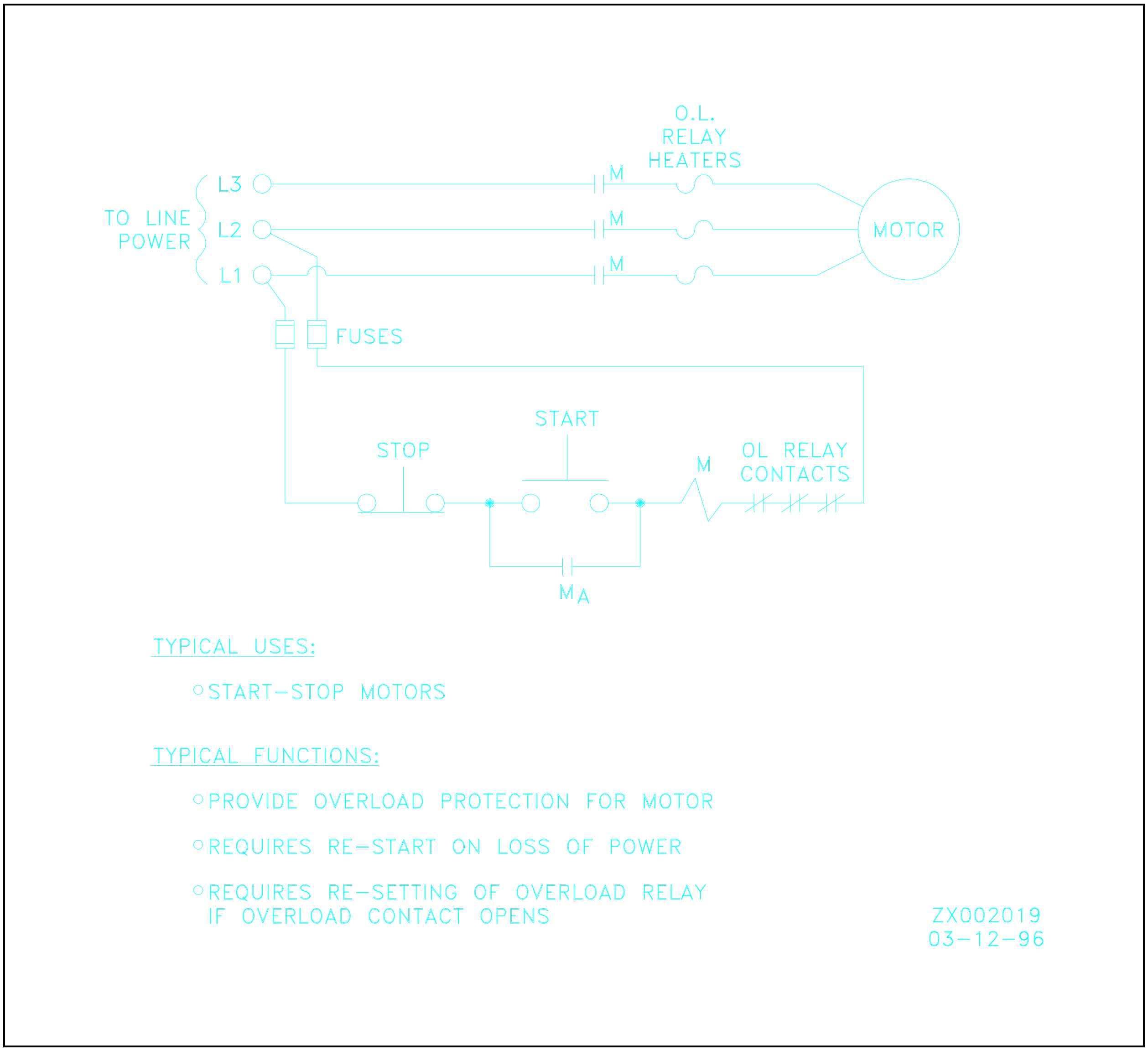


Figure 33 Non-Reversing Starter LVP Simplified Schematic

Typically, overloads are sized for a precise range of current. For example, if a motor full-load current were 27.0 amperes, a motor overload sensor may be selected for a range of 25.5 to 28.0 amperes. This overload relay would be calibrated to trip at a motor current slightly above the motor full-load current.

When the overload relay trips, it opens overload relay contacts in series with the M coil. This opens the motor M contacts and shuts down the motor. The overload relay contacts are designed to remain open after the overcurrent condition clears.

For the motor to be restarted, the overload relay must be reset. This usually requires several minutes of wait time to permit the overload relay to cool. If the motor is restarted too soon, the overload relay may trip again in a very short period of time. Once the overloads are reset, the motor may be restarted using the START pushbutton.

LVP Motor Controller with a Control Power Transformer (CPT) in a Motor Control Center

This circuit operates exactly the same as other LVP controllers; however, it contains a control power transformer (refer to Figure 34, *Non-Reversing Starter in MCC, LVP with Transformer*). This is a typical circuit used for the processes. In this case, the control power for the motor control circuit is provided through a control power transformer (CPT).

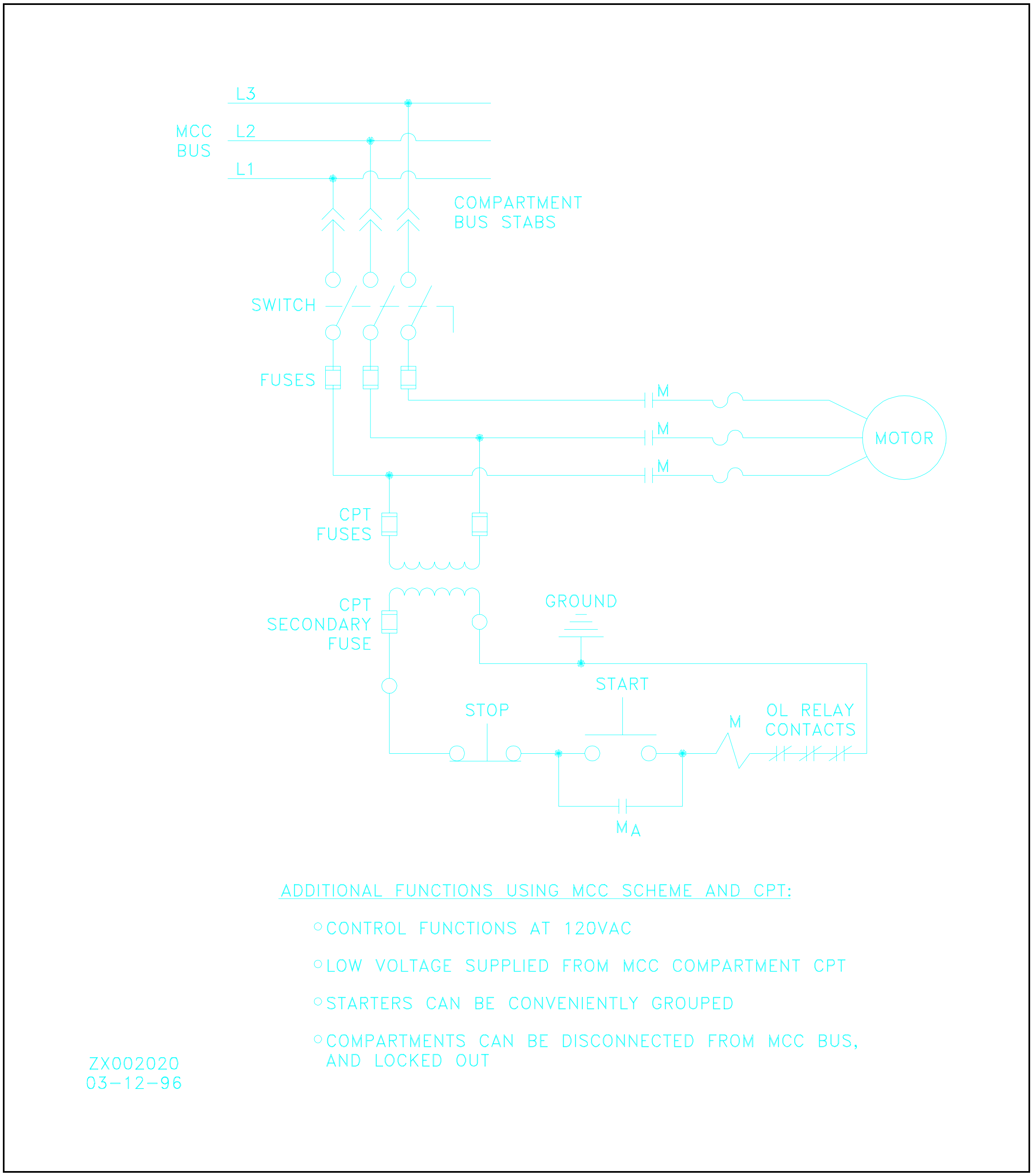


Figure 34 NR STR IN MCC, LVP With Control Power Transformer (CPT)

The START-STOP pushbuttons may be mounted at the MCC compartment or may be mounted at a different location and connected to the MCC compartment with cables. All starter and contactor MCC compartments in the CIF are equipped with a 480-VAC to 120-VAC single-phase CPT. This is done so that all control circuits are at a lower working voltage, and so that control circuits are isolated from the main 480-VAC power.

LVP Controller with Several Controlling Stations and an Interlock in a Motor Control Center

This circuit is similar to the LVP motor starter, but with the addition of extra START and STOP pushbuttons and one extra interlock which is wired into the main controller coil M circuit (refer to Figure 35, *Non-Reversing Combinations Starter in MC, LVP with CPT, Duplicate Pushbuttons and Interlock*).

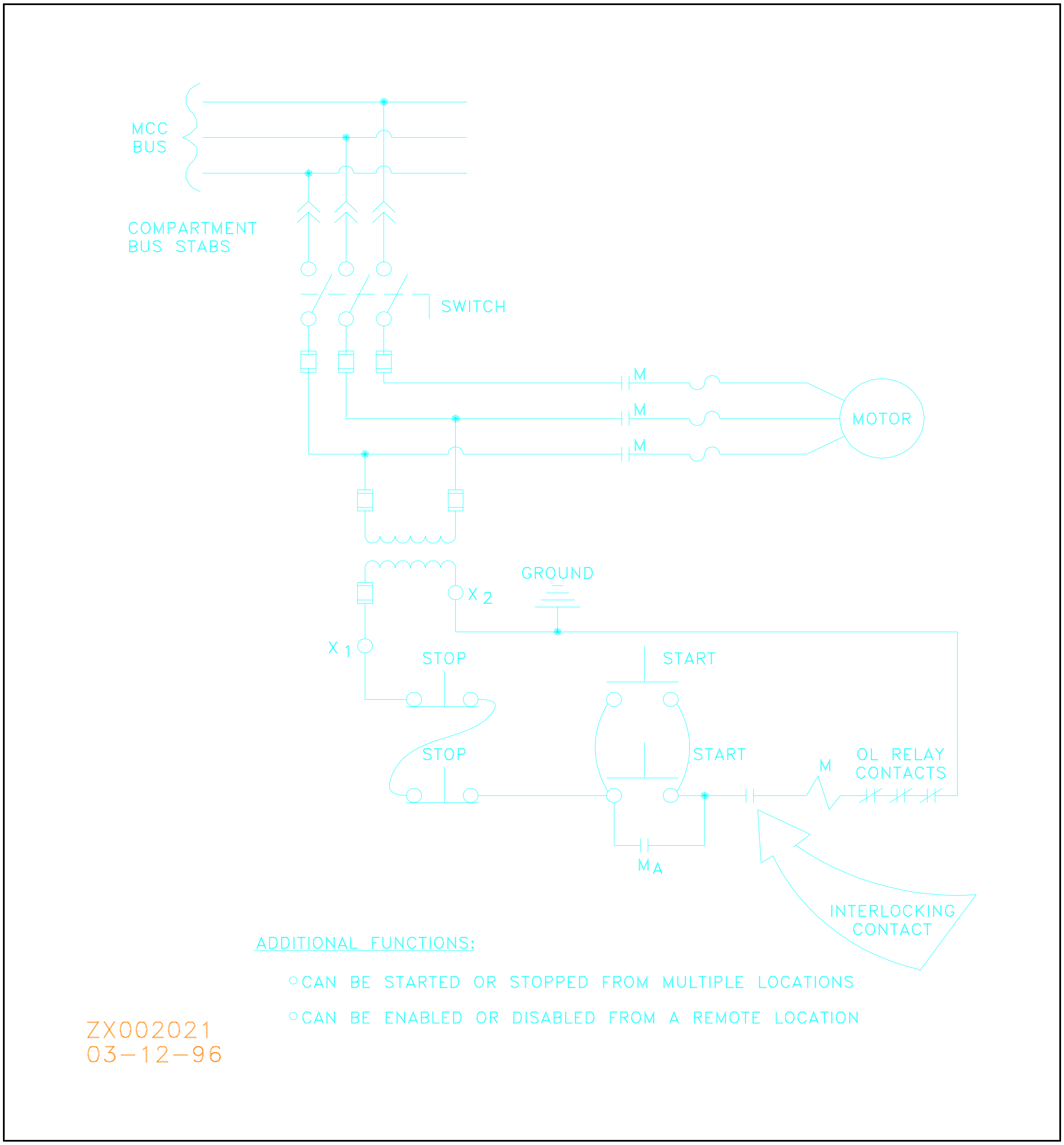


Figure 35 NR COMB STR In MCC, LVP With CPT, Duplicate Start-Stop Pbs and Interlocking

The extra START and STOP pushbuttons provide two locations from which the motor can be energized. The STOP pushbuttons are in series, so the circuit can be de-energized from either STOP pushbutton. The START pushbuttons are in parallel, permitting the motor starter to be energized from either pushbutton. The M_A contact closes in around either START pushbutton, which seals in the M coil regardless of which START pushbutton is used.

The interlocking contact is in series with the M coil. If this contact is open, the M coil will de-energize and cannot be re-energized. This interlocking contact acts as a "permissive" or "enabling" contact for this circuit. The interlocking contact could come from many sources:

- An auxiliary contact on another starter
- A contact at a sequencing relay panel
- A contact from I/O (input-output) circuits at the Programmable Logic Controller (PLC) or the Distributed Control System (DCS)
- A contact from a controlling device (such as a pressure switch or limit switch)
- A contact from any other source that is used to control motor operation

From an operating standpoint, the motor being driven by the circuit, if running, could be shut down by any of the following means:

- The STOP pushbutton could be pressed (from either operating location).
- The motor overload relay could open the overload relay contacts.
- The permissive interlock could be opened.
- The power supply to the motor could be lost.
- Control power could be lost (e.g., the control power transformer fuses blow).

In all cases, the starter must be manually restarted. If the overloads tripped, the overload relay must be reset before restarting.

LVP Starter in MCC with Multiple Pushbuttons, Interlocks, and Lights

Functionally, circuit operation is identical to the operation of Non-Reversing Combination Starter in MCC, LVP with CPT, Duplicate Pushbuttons and Interlock, except that extra pushbuttons and lights are installed (refer to Figure 36, *Non-Reversing Starter in MCC, LVP with CPT, Multiple Pushbuttons and Interlock*). The red lights are wired to bypass all circuitry. The red light indicates that there is power at the control circuit, but for some reason the motor is not running.

If the START pushbutton is pressed and the motor does not start, the probable cause is either the motor overload relay (OL contact open, which requires resetting the OL) or the system interlocking contact is open.

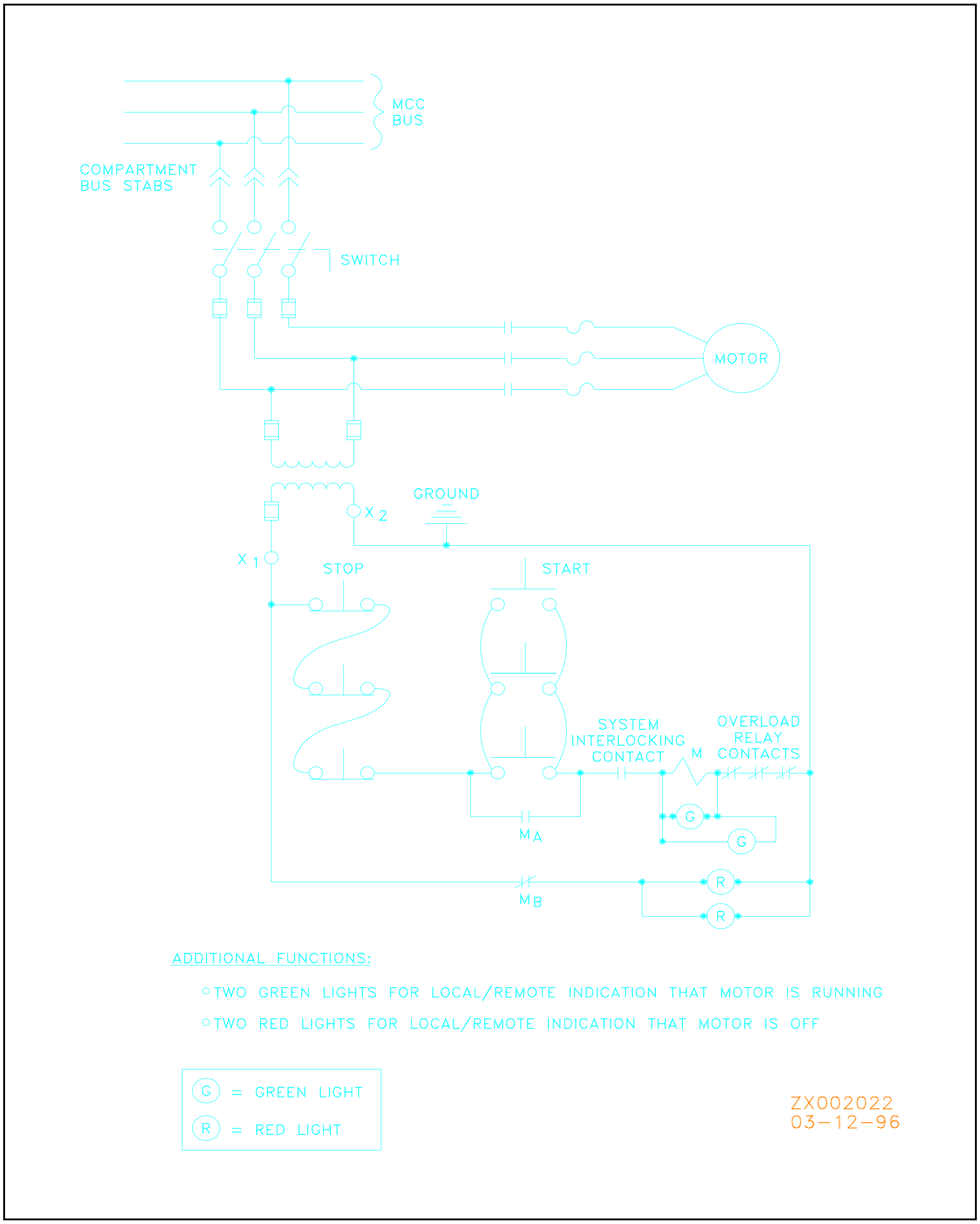


Figure 36 NR STR In MCC LVP With CPT Multiple Start-Stop Pbs and Lights and Intlk

Low voltage Release (LVR) Circuits

Low voltage release (LVR) circuits have the characteristic that if they lose supply power, the associated load will stop. When power is restored, the load will restart automatically. These circuits are used when it is desirable to:

- Restore the operation of equipment following a momentary loss of power with no operator action
- Simplify controller operation (LVR controllers are typically simpler in design and require fewer components.)

LVR Circuits

The basic difference between a low voltage release (LVR) circuit and the LVP circuit is that the LVR circuit contains a "maintained" contact pushbutton (refer to Figure 37, *Contactor LVR Circuits)*. In this case, when either the START or STOP pushbutton is pressed, the pushbutton will not return to its original position, but will latch into its pushed position. If power to the load is interrupted, the load will lose power, but the pushbuttons will remain in the actuated position. When power is re-established, it is not necessary to manually restart the load, because the START pushbutton will remain in the closed position, re-energizing the M coil. This circuit is referred to as an LVR circuit because when voltage feeding the coil is lost, the M coil de-energizes, and the load is released from the power supply.

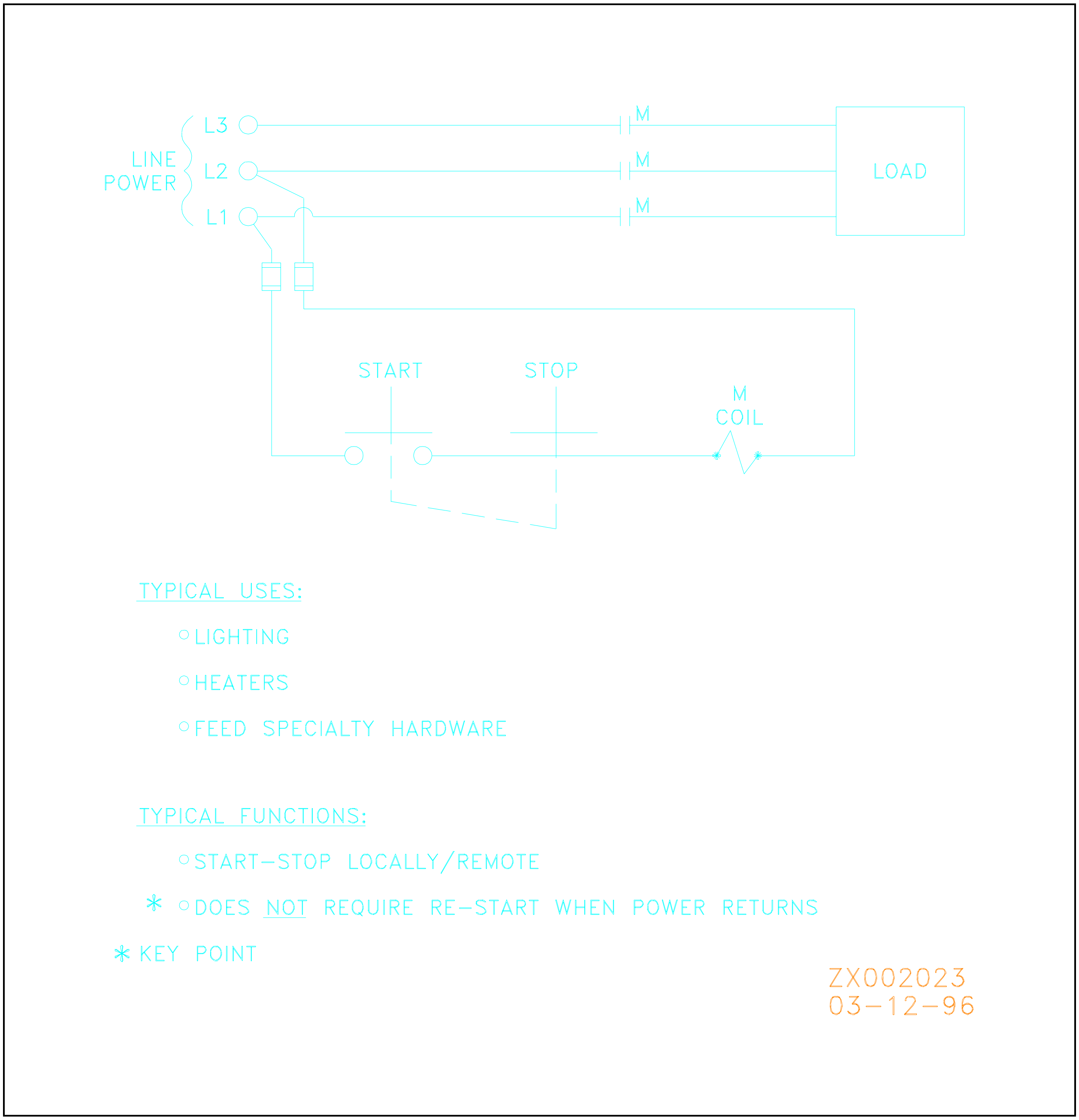


Figure 37 Contactor, LVR with Maintained Contact PBs

From an operating perspective, LVR circuits need not be manually restarted after power is restored following a loss of power. This could occur whenever there is a switch from normal to standby power or from standby power to normal power during operation of an automatic transfer switch (ATS). This circuit is typical for feeding lighting or heaters where there is no threat to Operator or Maintenance safety if power were to suddenly re-appear after a power outage. This circuit is also used for many motor circuits which are fed by standby power when it is desirable not to have to manually restart the motor loads upon loss and resumption of power.

LVR With Selector Switch Lights

This LVR circuit contains indicating lights (refer to Figure 38, *Contactor LVR Schematic Lights)*. The indicating lights function to indicate that the motor is energized (green light on) or de-energized (red light on).

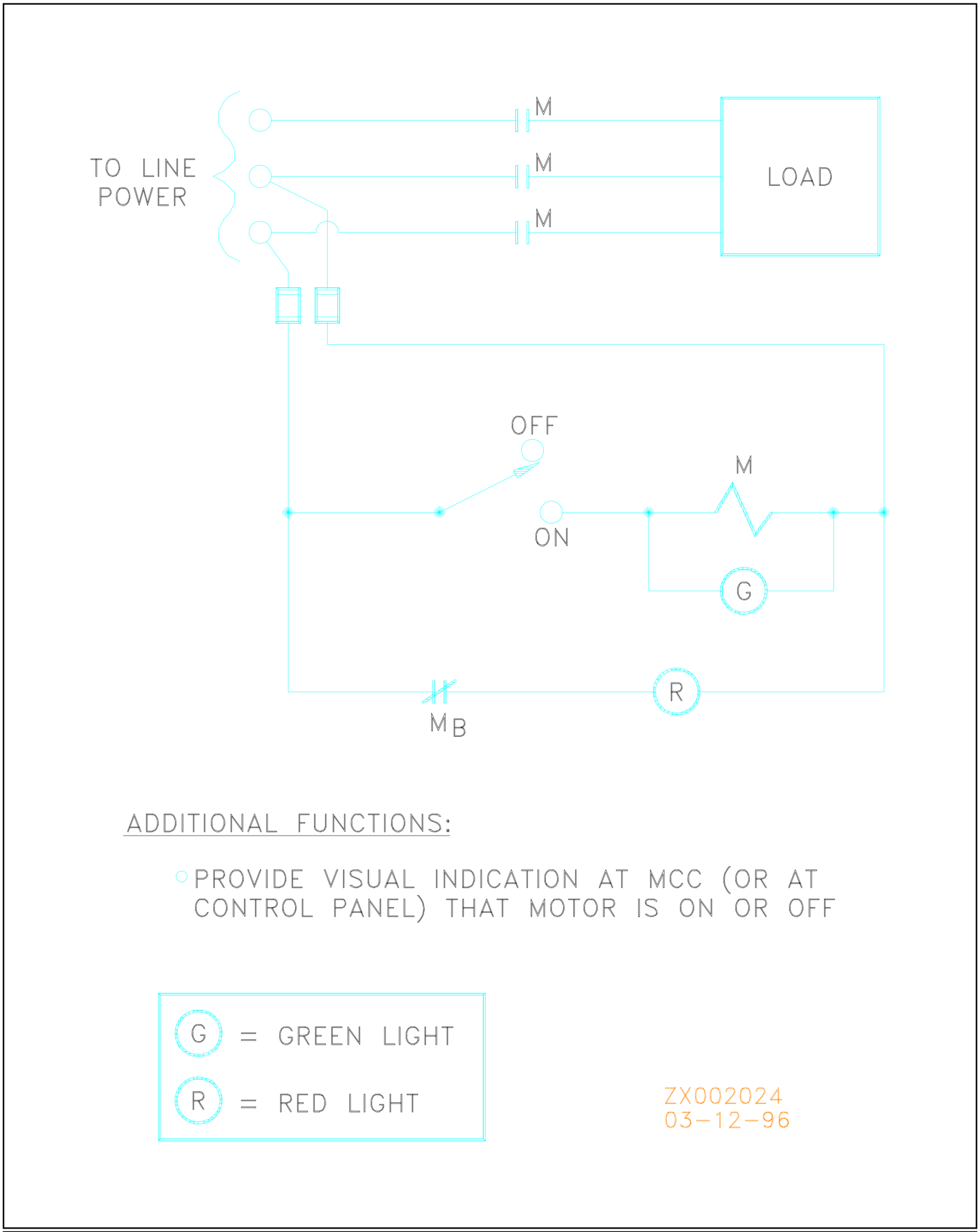


Figure 38 Contactor LVR with Lights

LVR With HAND/OFF/AUTO Selector Switch

These types of controllers are used for equipment that may be operated manually or automatically through the use of a signal from an outside device (refer to Figure 39, *Non-Reversing Starter with CPT, Hand-Off-Auto Selector Switch and Interlock)*. In this configuration, instead of using a two-position, maintained-contact selector switch, a three-position, maintained-contact selector switch is used. In the HAND position, this circuit functions the same as the simple LVR motor controller circuit. The circuit contains overloads which shut the motor down on a high-current condition. If an overload occurs, the selector switch remains in the HAND position, and the overload relay is reset; therefore, the motor would immediately restart. For this reason, whenever an overload occurs on an LVR circuit, the selector switch should be turned to the OFF position before the overload is reset.

When in the AUTO position, the motor is controlled from an outside device (e.g., temperature switch, pressure switch, level switch, etc.). When the device senses a parameter that requires that motor to be started, the controlling device will close its contact for the motor to start. If an overload occurs, the motor will shut down until the overload is reset, regardless of the position of the selector switch.

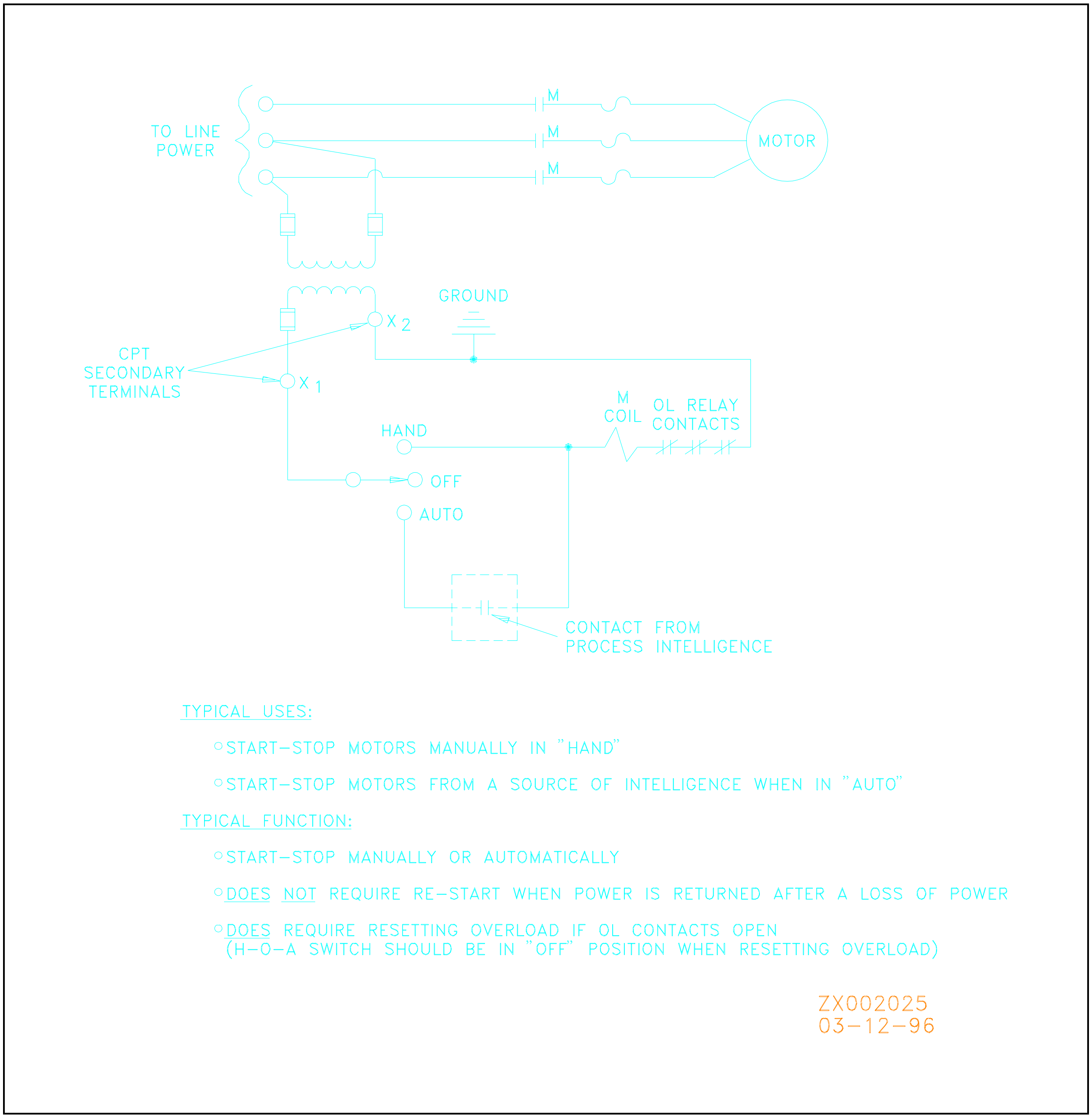


Figure 39 NR Starter with CPT, H-O-A SEL Switch and System Contact

LVR Starter in MCC With Lights and Interlocks

For this LVR circuit, the main contactor functions the same as for the other, more simple LVR circuits (refer to Figure 40, *Non-Reversing Starter in MCC with CPT, Hand-Off-Auto Selector Switch, Lights, System Contacts)*. This type of LVR circuit features multiple lights and interlocks. When the selector switch is in the AUTO position, the multiple interlock contacts must all be closed before the M coil can be energized. It is not unusual for a motor starter to depend upon several “permitting” or “enabling” contacts.

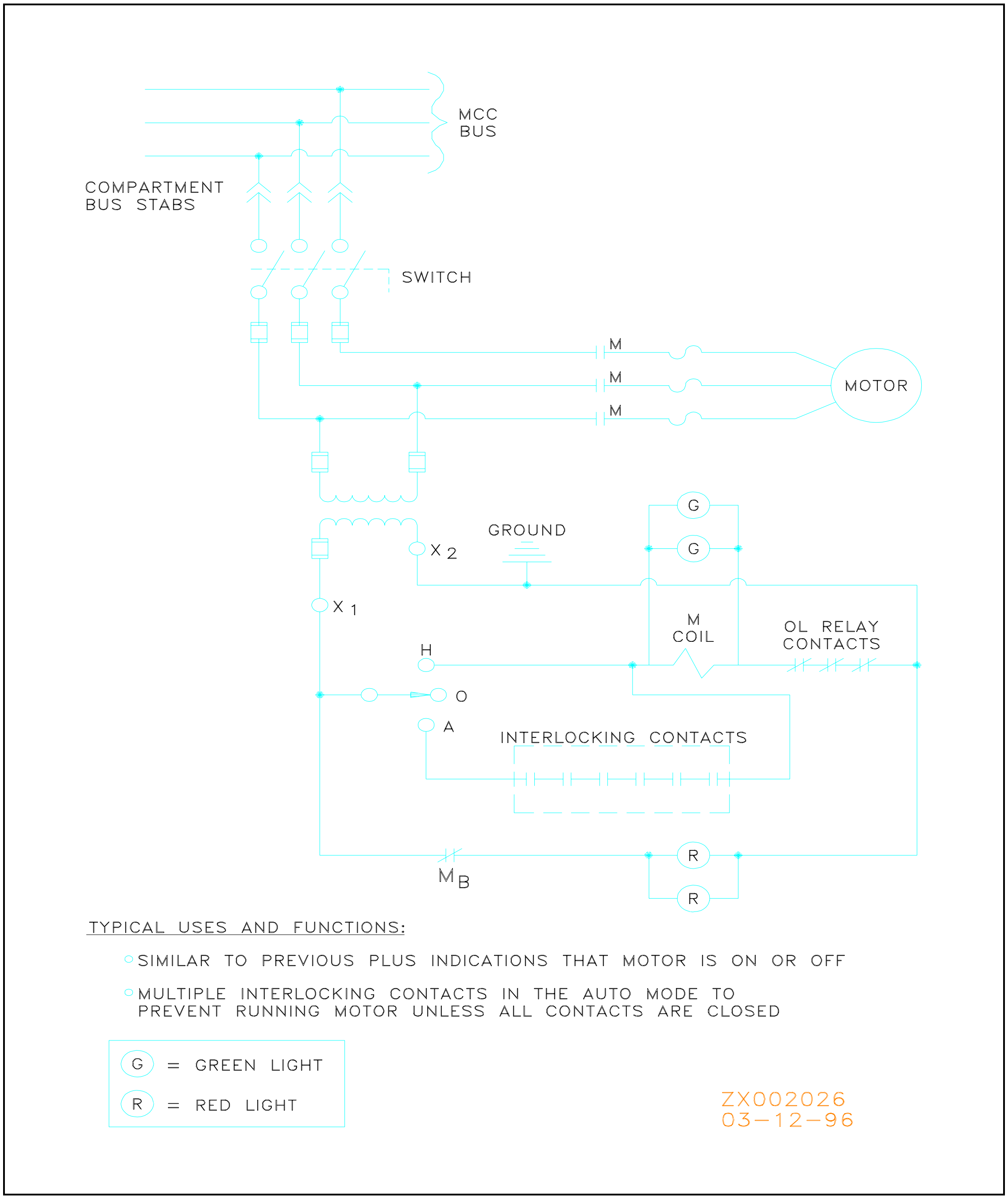


Figure 40 NR Starter In MCC With CPT, H-O-A and System Contacts

Facility Specific Controller Schematic Diagram

Many facility controllers utilize the same basic controller circuit, with minor alterations. Refer to Figures 41, 42, 43 and 44. The purpose of this review is to show how the Electrical Distribution System interfaces with the DCS. The DCS, in turn, assimilates data from the facility monitors to be certain that motors are not run during unsafe times.

Figure 41, *LVP With Light Schematic,* shows a standard LVP circuit with two M_A contacts. When the M coil is energized, the M_A contacts close. When the START pushbutton is closed, the motor is started by the M contactor (not shown), and the green light is illuminated. This circuit cannot be de-energized as shown.

Figure 42, *LVP/LVR With Light Schematic*, shows how the circuit can be de-energized by using the MAN-OFF-AUTO switch (by placing in OFF position). This circuit also shows how the motor could be started by placing the selector switch in the AUTO position, and having the SYSTEM CONTACT close. The SYSTEM CONTACT could be a limit switch, pressure switch, contact from a relay panel, etc.

Figure 43, *LVP/LVR with PLC Inputs/Outputs,* replaces the SYSTEM CONTACT with a signal from the PLC I/O cabinet (mounted adjacent to the MCC). The green light has been replaced with a signal to the PLC I/O cabinet. A 120-VAC input signal means that the motor is running. As the system was originally designed, when running in the AUTO mode, and when the START pushbutton is pushed, an instantaneous 120-VAC signal is sent to the PLC I/O cabinet. This procedure could be used to alert the DCS operator that power is available at the MCC cubicle.

This system is presently configured such that when a DCS signal is sent to the control circuit, the DCS screen flashes red. If the motor starts, the DCS shows a green constant light, indicating that the motor has started. If the motor does not start in 3 seconds, the signal from the DCS to the controller is stopped but the screen flashes green. This alerts the operator that the motor has not started.

This schematic, as shown, is typical for several drives at CIF such as: Fuel oil unloading, fuel oil feed pump, fuel oil transfer, blend tank agitators, rad oils/solvent unloading pump, rad organic feed pumps, waste tank agitators, caustic unloading pump, clean sump pump, regulated sump pump, quench recirculating tank agitator, scrubbed recirculation tank agitators, ID fan motors, filter feed tank agitators and blowdown tank agitators.

Slight modifications to this circuit are typical for tank farm vacuum blowers.

Figure 44, *Typical CIF Controller*, shows a circuit similar to the above, but with additional system interlocks. The limit switch contact and the pressure switch contact are always in the circuit whether the operator is running in manual or automatic. These types of interlocks are used for feed pumps and transfer pumps to make certain that material will not be transferred to a holding tank (or from the tank) unless there is space for the material. An example is a thermosyphon tank. The thermosyphon tank has a pressure switch and a level switch. If either of these switch contacts are not closed then the pump is shutdown.

Other types of interlocks may be used instead of pressure switches. For example, conveyors are equipped with a master E-STOP. The E-STOP switches energize a relay that in turn opens up a contact very much like the limit switch or pressure switch contacts shown on Figure 44. In this manner, several conveyors can be immediately stopped by pressing one “E-STOP” button.

This schematic, as shown on Figure 44, is typical for several drives at CIF such as: Blend tank recirculating pumps, tank transfer pumps, aqueous waste transfer pump, quench recirculation pumps, scrubber recirculation pumps, filter feed pumps, filter concentrate transfer pump, blowdown transfer pumps, various conveyors and turntables (Emergency stop instead of interlocks).

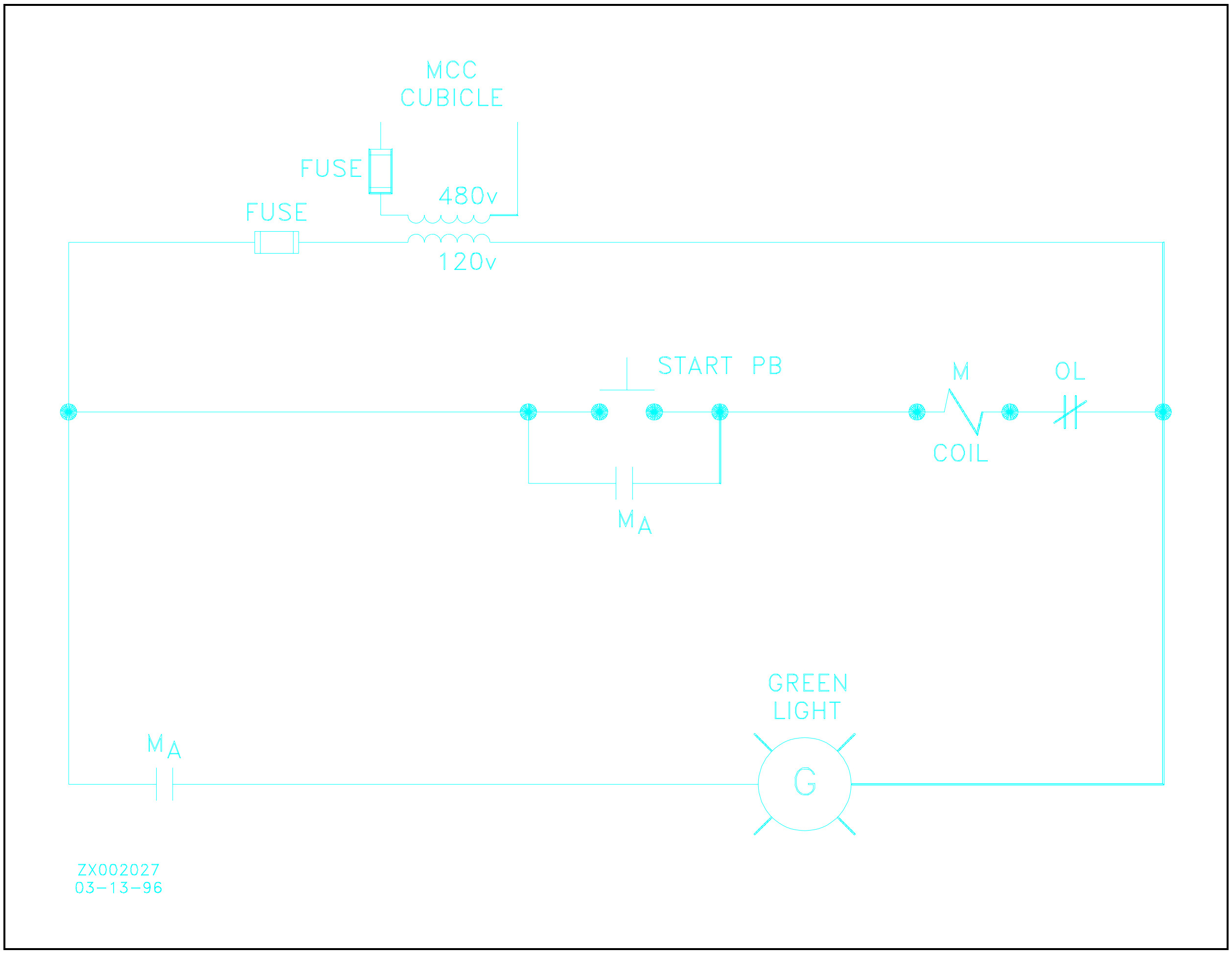


Figure 41 LVP With Light

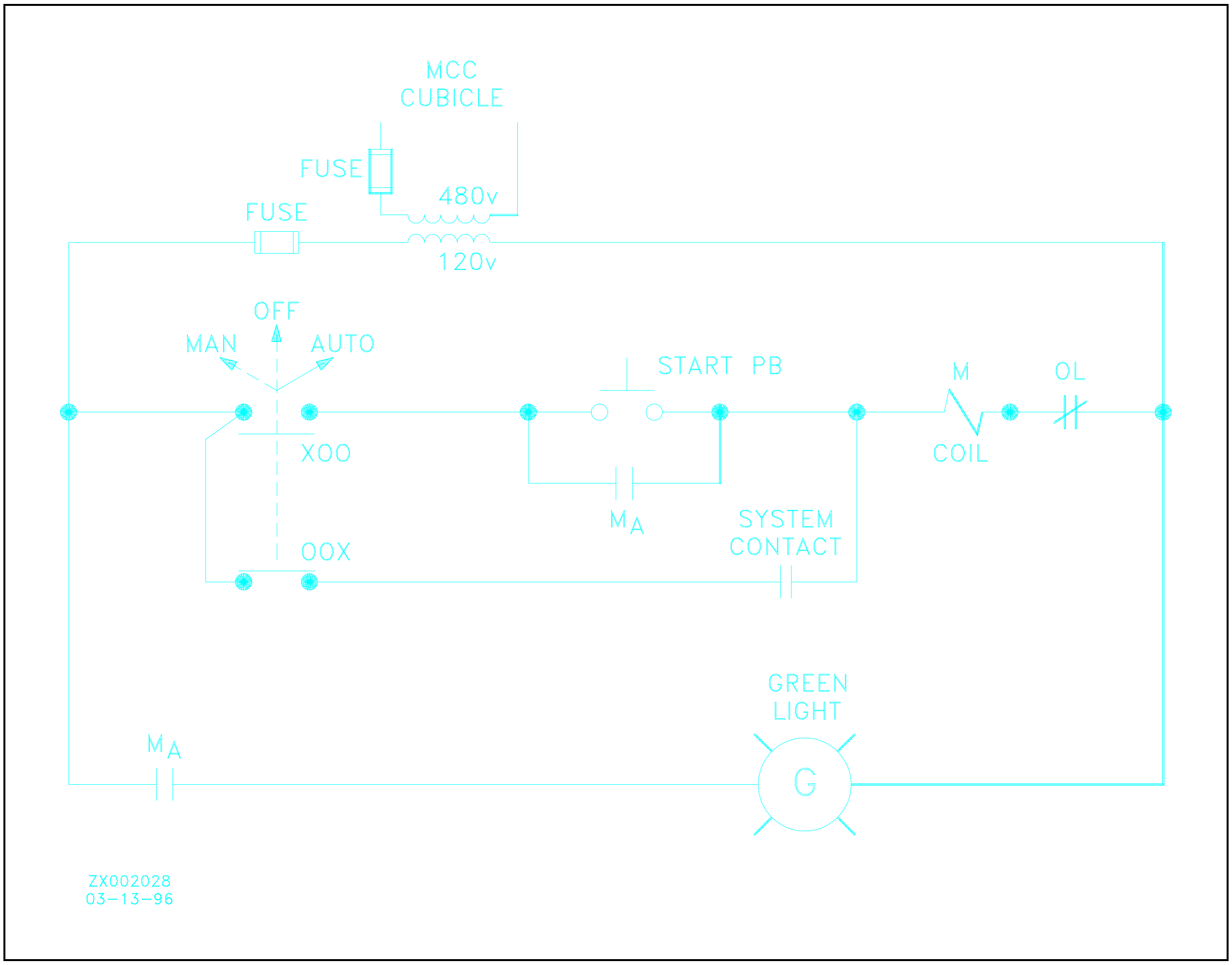


Figure 42 LVP/LVR With Light

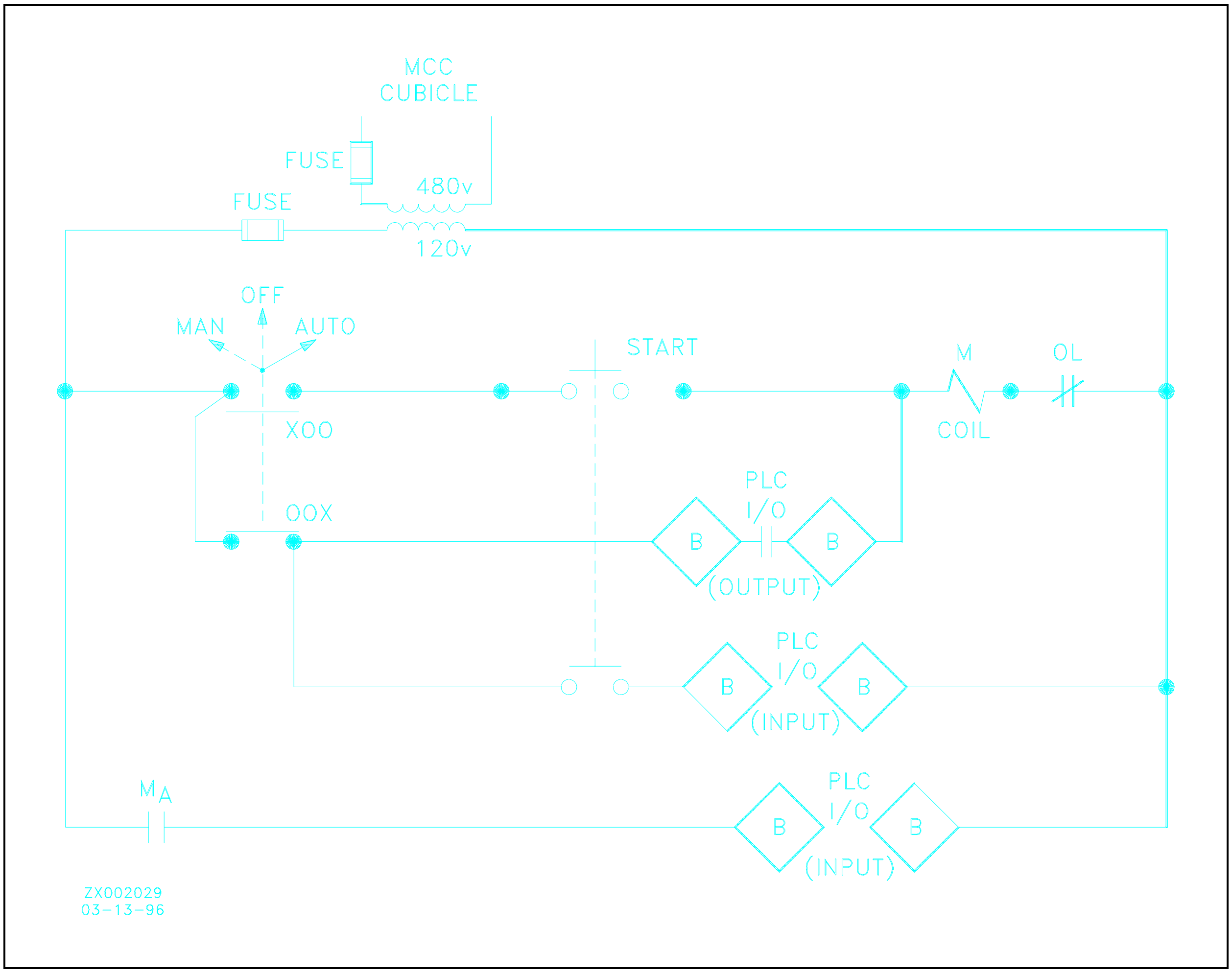


Figure 43 LVP/LVR With PLC Inputs/Outputs

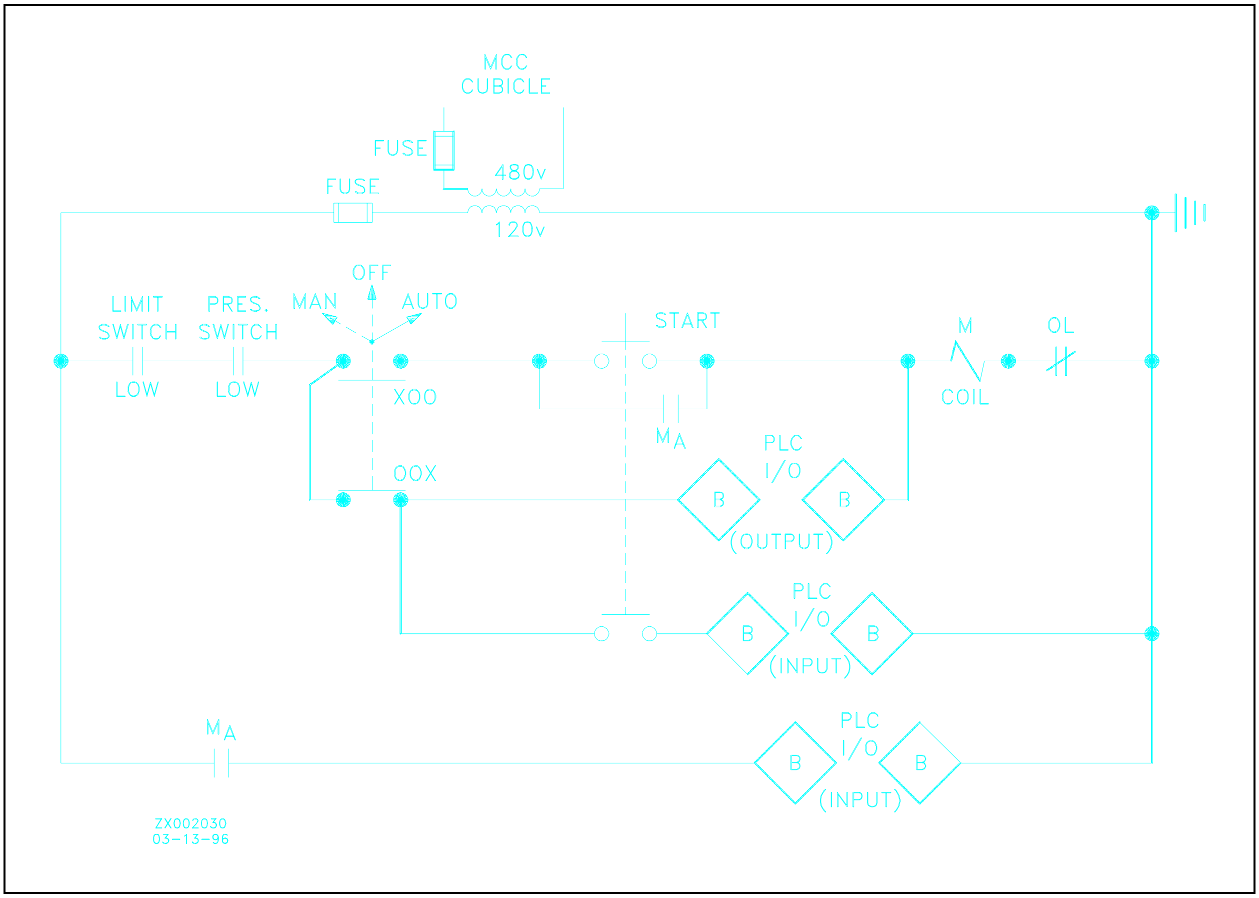


Figure 44 Typical CIF Controller

INTEGRATED PLANT OPERATIONS

This section describes different types of abnormal operations of the Tank Farm Electrical Distribution System and the interrelationship of electrical systems with other systems in the HLW-Area.

6.01 Given a single-line diagram of the Electrical Distribution System, EVALUATE abnormal power conditions and DETERMINE operator actions required to re-start loads.

6.02 Given a single-line diagram of the Electrical Distribution System and further given a scenario of a localized fault condition, IDENTIFY the electrical device that will operate to clear the fault condition.

6.03 STATE the responsibilities of the CIF-Area operators as related to the boundaries of the Electrical Distribution System.

Introduction

The Site Utilities Department (SUD) dispatcher is responsible for controlling all 115-kV breakers and all 13.8 kV area substation breakers. CIF Operations Department is responsible for coordination with the SUD dispatcher to ensure that appropriate 13.8kV breakers feeding to the H-Area Distribution Substations are racked in and ready to supply power.

SUD is responsible for the 480VAC distribution substation main breaker in compartment 1B of substation switchgear SWGR-001. CIF Operations is responsible for all equipment downstream of breaker 1B. SUD never operates the 13.8 kV substation main disconnect switch, unless the main breaker 1B is de-energized (open); therefore, coordination between groups is essential.

System Startup - Normal Operations

The substation transformer has power available and has been energized by the Power Department. The substation 480V switchgear circuit breaker MCCs are aligned for energization per applicable alignment checklist. The alignment checklist for energizing closes all of the switchgear breakers with the exception of switchgear 3C, which is opened or verified open. Switchgear breaker 1B will be operated by the H-Area Power Operations group.

Component operation shall be from the DCS when the capability exists. The Shift Supervisor must approve any deviations from prescribed alignment in the procedure(s).

The nominal voltage on the secondary side of the substation transformer will be verified to be 480VAC as indicated on the local breaker. The ATS alignment will be verified.

When this section of alignment is completed, operators may proceed to energize the individual

MCCs. This is done per applicable attachments in the procedure. As previously mentioned, there are eight (8) MCCs. Each MCC is protected by a fused disconnect switch to allow for emergency isolation. The individual equipment compartments on each MCC are protected by combination fused disconnects, magnetic controllers, control transformers, and motor overloads. Operators need to ensure adherence to safety precautions referenced in Manual 8Q, *Employee Safety Manual*, when manipulating breakers for start-up alignment.

MCCs are energized by closing the MCC compartment switch in each of the compartments. After this has been performed, operators may align the loads off the MCC as required for facility status. MCC compartment switch alignments need not be performed in sequential order as specified in the applicable attachments, unless otherwise stated in the assignment sheet(s). Any problems that occur when operating switches (i.e., improper indications, unusual noises, abnormal events, etc.) need to be reported to the Shift Supervisors.

The alignment of MCCs 7 and 8 requires ensuring the proper positioning of the ATSs. Operator verifies this by observing the D/G IN AUTO START MODE green indicating light on the emergency diesel generators local control panel and ensuring it is illuminated. The retransfer switch on the ATS should be in the automatic retransfer position. This has previously been accomplished during the substation alignment but the operator needs to recognize the normal and emergency lineups of the ATSs for the purpose of performing routine and infrequent surveillances and inspections.

The 208/120v alignment consists of closing the breakers for the power or lighting panel(s) to be placed in service and performing the applicable attachment(s) for the individual breakers as required for facility status. Again, breaker alignments need not be performed in sequential order as specified in the applicable attachments, unless otherwise stated in the assignment sheet(s). The UPS must be on-line before closing in breakers on instrument power panel A-F, & M.

The UPS consists of a battery charger, batteries, an inverter, and the manual and automatic controls supplying essential power to the instrumentation and control panels. There are normal and alternate feeds for the UPS; the normal feed is from MCC 7 to the UPS battery charger, and the alternate feed is from MCC 8 through a step-down transformer to the AC bypass switch and out to the 120V panels. Therefore, prior to placing the UPS in service, MCC 7 must be energized to provide normal power feed, or MCC 8 must be energized to provide alternate feed as specified. The battery breaker, the normal AC power supply breaker, and the bypass breaker on the UPS control panels must be closed.

The 480V supply disconnects to the UPS must be closed. First, the equalizer/float toggle switch should be in the FLOAT position. (See items 1, 2 and 3):

1. The pre-charge pushbutton is depressed until the yellow pre-charge light is illuminated, indicating sufficient charging. The battery input breaker is placed in the ON position.
2. The AC input breaker is placed in the ON position.
3. Then, the bypass source AC input breaker is placed in the ON position. The manual bypass switch is placed in the NORMAL INVERTER position. The inverter to

load/bypass source to load hand switch is placed in the INVERTER TO LOAD position.

When the UPS component positioning has been performed, the operator will verify UPS-indicator status by performing the specified attachment. This attachment requires the operator to verify that all required indicating lights are illuminated. The operator then verifies the DCS point tag display alarm status as specified on the applicable attachment to document that required DCS alarms are enabled. Finally, the operator inspects the inverter output voltage and amperes (for each of the three phases) and the inverter output frequency. Operator will also verify that the UPS TROUBLE alarm is indicating OFF.

System Shutdown

System shutdown is performed in the reverse of system startup. Breaker, panel, and MCC manipulation will be performed in conjunction with shutdown of applicable systems and will be coordinated through the Shift Supervisor and any other cognizant authorities.

Localized Faults

Localized faults are caused by abnormal operations of process components, instruments, or control components. Examples of localized faults are: Motor overloads, equipment over temperature (from overload or ambient conditions), inadvertent short circuits in cables or in equipment, miscellaneous local voltage surges (caused by process fluctuations), and protective device malfunctions (circuit breakers and fuses).

There are two (2) general types of circuits in the CIF Electrical Distribution System: motor circuits and panel board circuits. These type of circuits are similar, but motor circuits have the ability to accurately protect motors from long-term overload conditions.

Motor Control Circuit Protective Devices

Figure 45, *Arrangement of Protective Devices for Motor Controls)* depicts the typical arrangement of electrical protective devices for a circuit feeding a motor controller (starter).

The important fact to note is that when a fault occurs, the electrical current that flows into a fault flows all the way from the electrical generating point (400 Area and purchased power generators) through the complete system and to the fault. For example, suppose that all the feeder cables between the local motor disconnect switch and the motor were suddenly tied together, as they would be in the case of someone accidentally cutting all three cables with a shovel. This would create a “short circuit,” which is an electrical fault. Short-circuit current (very high) would flow through all protective devices shown on Figure 45 at the same time. If this high value of current exceeds the rating of the protective devices, each protective device initiates its own fault shut-down action.

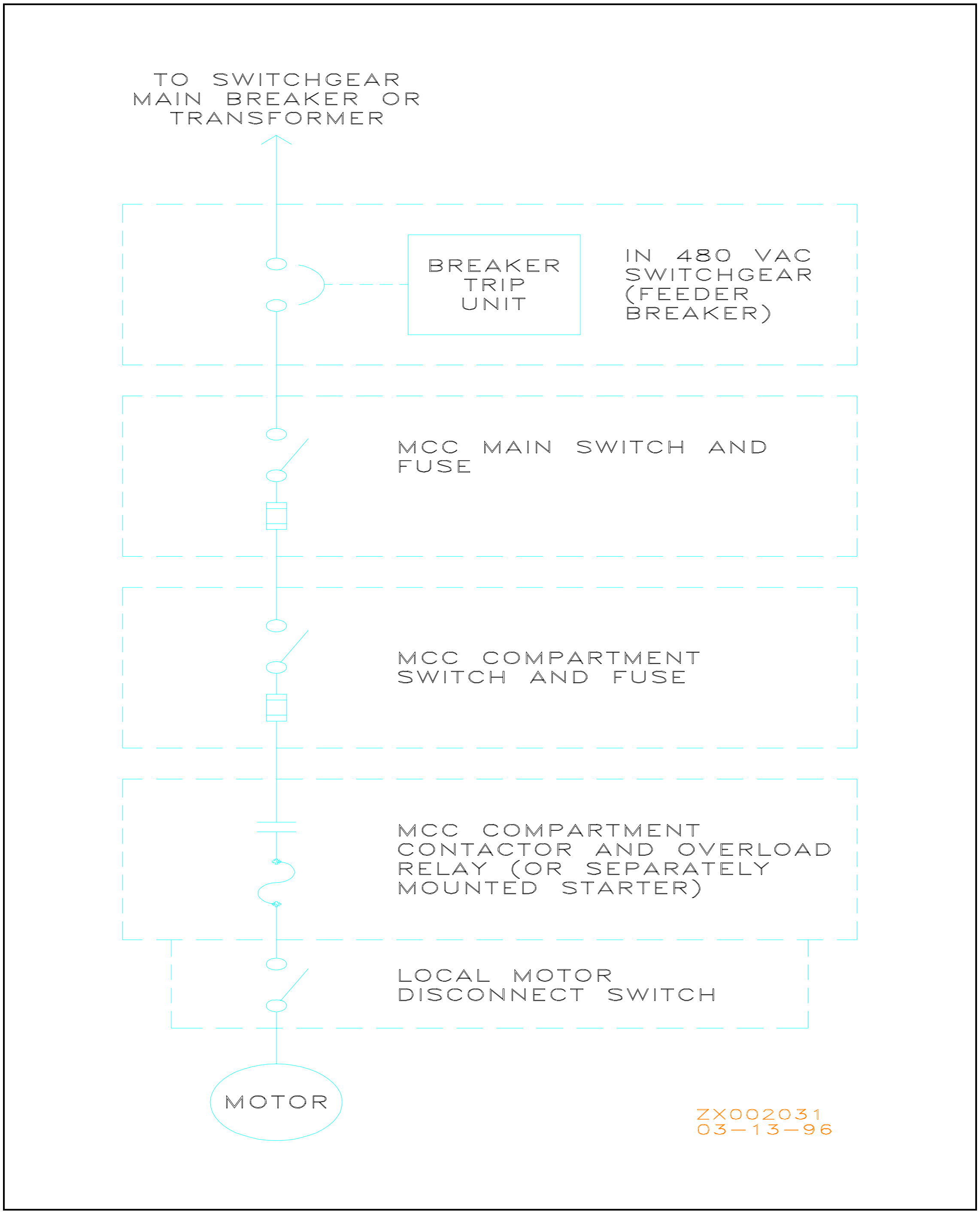


Figure 45 Typical Arrangement of Electrical Protective Devices for Motor Controllers

The MCC compartment overload relays start to initiate a contactor opening sequence, but because the overload relay is a thermal device, it requires considerable time before it actually opens the contactor.

The MCC compartment switch and fuse utilize fuses that are designed to blow at high current in a very short period of time (for example, in cycles or Hz). These quick-acting fuses would clear the short-circuit fault.

The question is, why do the MCC compartment fuses blow, but the MCC main fuses do not? In a properly coordinated electrical system, fuses in series are selected such that main fuses are always larger than those further downstream. For example, suppose that the main MCC fuses are 600 amperes (continuous rating) and the MCC compartment fuses are 50 amperes (continuous rating). If the short circuit current to the fault were 8000 amperes, for example, the fault current would be 13 times the main fuse rating but 160 times the compartment fuse rating. Fuse trip time is inversely related to the percentage of overcurrent beyond the fuse continuous current rating. Therefore, the compartment fuses would blow much quicker than the main fuses.

In a similar manner, the switchgear feeder breaker feeding to an MCC main switch and fuse are coordinated so that for a given fault current, the MCC main fuses will blow before the switchgear feeder breaker trips.

In a properly designed electrical system, only those protective devices nearest to a fault should operate. In this manner the fault can be constrained to a small area and the un-faulted electrical system can continue to operate.

Overload relays used in motor starters are designed for protecting motors against only long term (minutes or hours) overloading conditions. When overload relays trip, they are designed to open the starter coil circuit, thereby dropping out (opening) the contactor that feeds power to the motor. Contactors are not designed to open under short circuit conditions. All efficient electrical systems, such as the ones in the CIF Areas, include fuses with each starter so that the fuses rather than the overload relay and contactor, will blow to clear a short circuit.

Panel board Circuit Protective Devices and Localized Faults

Figure 46 depicts a typical arrangement of electrical protective devices for a panel board circuit. In this instance, an electrical fault in the circuit being fed by a panel board feeder breaker should be cleared by that breaker. One of the most difficult aspects of sizing panel board breakers is the fact that when initially designing an electrical system, the panel board loads are the least predictable. When additional lights or instruments are added to an existing system, the added loads are typically added to an existing panel board breaker load, thereby causing troublesome overloads and breaker trips. Because of these nuisance trips, SRS operators have been permitted to reset panel board breakers one time, only after having found the cause of the overload and correcting the problem.

The coordination among panel board breakers and upstream devices is similar to that for motor circuits; the protection device nearest to an electrical fault should be the only device to operate under fault conditions.

The functions of the devices depicted in Figure 46, *Arrangement of Protective Devices for Panel Board Loads* are explained briefly below:

- Panel board feeder breaker - protects a particular circuit from overloads or short circuits, and protects both the loads and the cables leading to the loads.
- Panel board main breaker - acts as a back up to panel board feeder breakers and protects against electrical faults in the panel board itself.
- Power transformer disconnect switch - a safety disconnect at the control power transformer, which may or may not be fused.
- MCC compartment switch and fuse - disconnects the circuit from the MCC bus. (The switch is the device that is designated to be either OPEN or CLOSED in breaker lineups shown in operating procedures). The fuses protect the CPT and the cables to the CPT.
- Main MCC switch and fuse - protects against faults in the MCC bus and serves as backup for the MCC compartment fuses.
- Switchgear feeder breaker - protects feeder cables between switchgear and MCCs.

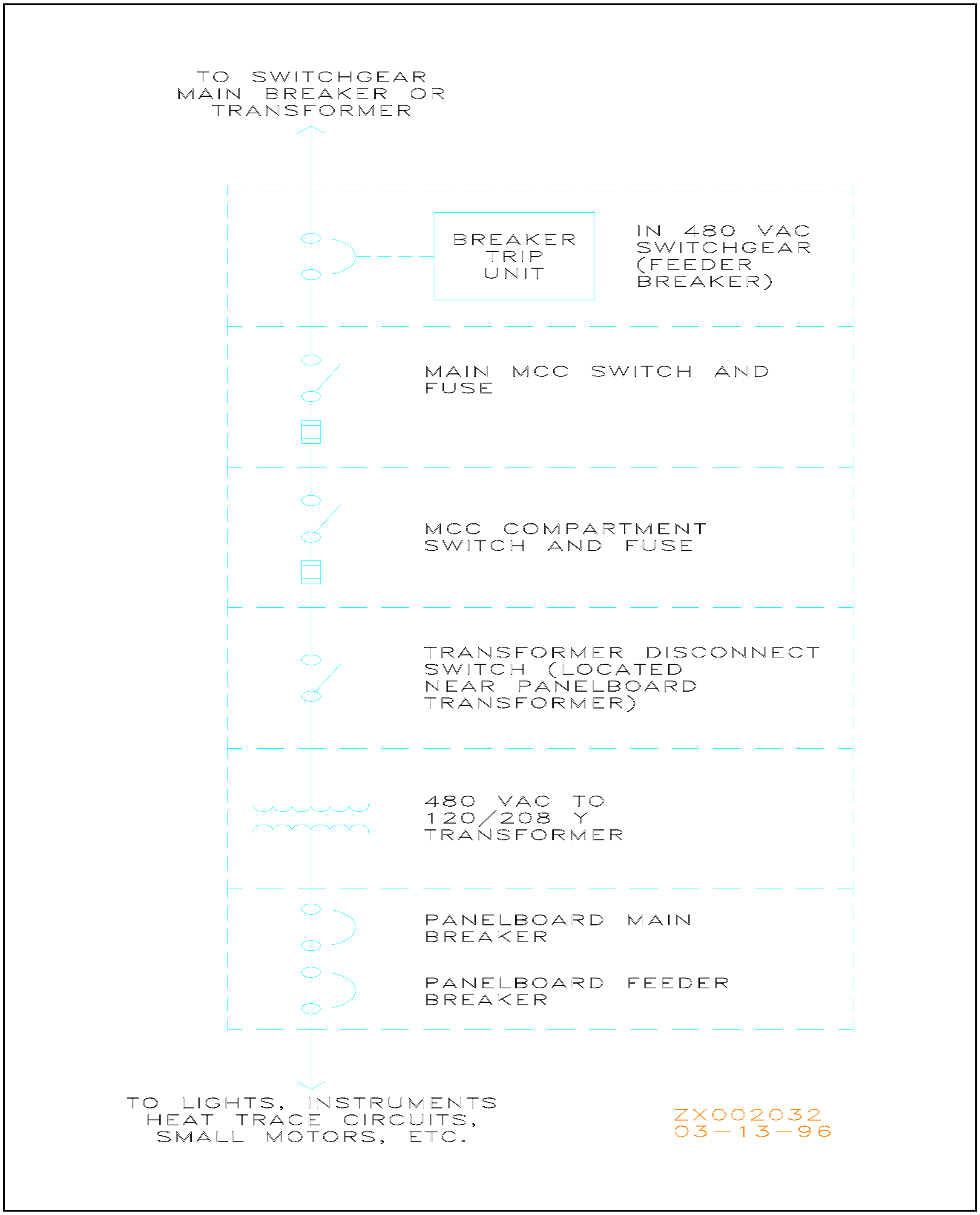


Figure 46 Typical Arrangement of Electrical Protective Devices for Panel board Loads

Abnormal Conditions

The most serious electrical condition possible is a complete facility loss of power. In this case the two CIF SDGs can handle all loads on MCC 7 and MCC 8 so that an orderly process shutdown can be achieved.

For a general loss of power, the following sequence/operator actions apply:

1. Loss of power: all loads except those fed by the UPS are de-energized
2. After 1 second: Two ATSs start SDGs.
3. After SDGs are at rated voltage and frequency (10-15 seconds), ATS switches MCC-7 and MCC 8 to be powered from SDGs. UPS batteries start to re-charge, and the UPS battery charger assumes the UPS loads.
4. Operations must re-start LVP loads on MCC 7 and MCC 8 in accordance with re-start procedures (LVR loads and panel boards require no operator intervention). All alarms on DCS acknowledged.
5. SDG operation closely monitored until power is restored. Parameters of SDG to be monitored, and fuel level specified in procedures.

Loss of Normal Power

The above-described process is the same for both ATSs and diesel generators. Therefore, it is expected that both diesel generators will be started and at full voltage and stable 60 Hz frequency within 15 seconds of a loss of normal power incident. However, no loads on the standby buses are required to have power for 15 minutes after a loss of normal power. Thus, the diesel generators are considered standby diesels instead of emergency diesels. Also, the loads on MCC 7 and MCC 8 are redundant. If only one diesel generator starts, the incinerator can still be safely shut-down.

Once the diesel generators are at full voltage and stable frequency, the motor loads should be sequenced on the standby buses. Sequencing the motor loads prevents the diesel from becoming overloaded and possibly failing due to the high inrush current caused by starting a motor. Typically a motor inrush current is six times its normal fully rated current. Once the standby MCCs lose normal power, the motor starter M contacts will open. When the ATS ties the standby diesel to its standby bus, the diesel has no motor loads on it. However, it does have its diesel power panel and UPS battery charge for standby MCC 7 or UPS alternate feed for standby MCC 8. These feeds are on disconnect switches which remain closed during the loss of a power incident.

Presently, the automatic sequencer logic has been incorporated. The facility PLC will remain energized during a loss of normal power, since it is fed from the UPS. The sequencer is expected to be modified to have a few changes for only one diesel generator running these may include:

ID Fans

Three are provided, with two on MCC 7 and one on MCC 8. Only one is required to maintain negative pressure on the system and keep the kiln purged to prevent an explosive condition. A software interlock prevents running more than 2 fans.

Quench Recirculating Pumps

Two are provided, with one on each of the standby MCCs. Scrubber Recirculating Pumps. Both pumps can be run at the same time but one the required flow in established from only one.

Scrubber Recirculating Pumps

Two are provided, with one on each of the standby MCCs.

Process Water Pumps

Three are provided, with one on MCC 7 and the other two on MCC 8. One is required to maintain cooling water to the scrubber and quench system equipment.

Caustic Pumps

Three are provided, with one on MCC 7 and the other two on MCC 8. One is required to prevent an acid condition that would cause corrosion damage to the off gas equipment.

Cam Vacuum Blowers

Two are provided, with one on each of the standby MCCs. Only one of two blowers can be running to maintain operation of continuous air monitor instrumentation in the building areas this is a hard wired interlock.

Sequencer General

The Sequencer does not control the Cam Blowers, Tank Farm CAM Blowers, or Building Exhaust Fans. These loads are controlled by relays not the PLC's or PCS. Operators must manually start these load in order of significance, for instance the Main Exhaust must be started first since it is the largest load.

On a one diesel start, it may be necessary to change the position of the manual transfer switch H-261-EEP-MTS-001 in order for Instrumentation Power Panel G to be energized.

On a two diesel start it may be necessary to shutdown some of the redundant loads. Like Quench Recirc Pumps, Srubber Recirculation Pumps, or Process Water Pump.

Tank Farm Cam Vacuum Blowers

Two are provided, with one on each of the standby MCCs. Relay interlocks prevent both Farm CAM Vacuum Blowers from operating at the same time.

Ram Feed Housing Purge Blower

One is provided on MCC 7 to avoid explosive gas mixtures from developing in the Ram Feed Area.

Building Exhaust Fans

Two are provided, with one on each of the standby MCCs. Relay interlocks prevent both building exhaust fans from operating at the same time.

If both diesel generators are running, then the load should be divided between the two diesel generators. Presently, interlocks prevent the following redundant loads from operating at the same time: CAM vacuum blowers, tank farm vacuum blowers, and building exhaust fans. There are no interlocks to prevent running the quench recirculating pumps, or scrubber recirculating pumps simultaneously, but only one is required. Also, under no conditions should more than two ID fans be running. The load sequencer will address starting loads with a two-diesel-generator start.

After a return of normal power:

a) After 30 minutes of stable normal power, ATS automatically switches loads to normal source. All loads except those fed by the UPS are de-energized.
b) Five minutes after ATS switches loads to normal, ATS shuts down SDGs automatically.
c) Operations must re-start all LVP loads on MCC 1 through MCC 8 in accordance with re-start procedures. All alarms on DCS acknowledged.
d) SDGs are secured and fuel oil level checked.

<u>Summary</u>

- The CIF Electrical Distribution System contains electrical protective devices in each major component which are designed to protect their respective components and cabling to downstream components. By selecting specific tripping characteristics, protective devices can be coordinated such that local electrical system faults can be cleared with minimum overall electrical system degradation. Some loads can be on the Diesel Generator as soon as the ATS switches to the Emergency Position: The Tank Farm SAAM System, and the Rotary Kiln Drive Unit are powered from the Diesel Generator #1 system, and the HVAC SAAM system and, SAAM are powered from Diesel Generator #2 system. UPS, Diesel Power Panel, Off Gas also receive power.

RELATIONSHIP TO SAFETY ENVELOPE

The purpose of this section is to alert operators to the importance of safety around electrical equipment and the requirements of periodic tests on standby diesel generators.

Introduction

This section consists of a brief discussion of related Operational Safety Requirements (OSRs) and site Incident Reports.

No Limiting Conditions of Operation (LCOs) apply to the Electrical Distribution System.

The SAR *200-H-Area Analysis of Operations,* WSRC-SA-17, indicates the following regarding the Electrical Distribution System. (Reference numbers are from WSRC-SA-17.):

9.3.18.4 Analysis of Effects and Consequences

The CIF is capable of complete and safe shutdown during all credible Abnormal Operating Events (AOEs). The worst consequence of any credible loss of normal power is an immediate shutdown of the CIF.

9.3.18.4.1 Radiological Consequences

There are no radiological consequences as a result of AOEs in the Electrical System.

9.3.18.4.2 Nonradiological Consequences

There are no nonradiological consequences as a result of AOEs in the Electrical System, except for those events that impact facility operation, as discussed in Section 9.3.18.4.

9.3.18.5 Analysis of Risk

There are no risks as a result of AOEs in the Electrical System except for interruption of facility operation.

9.3.18.5.1 Radiological Risk

There are no radiological risks as a result of AOEs in the Electrical System.

9.3.18.5.2 Nonradiological Risk

Except for the risks discussed in Section 9.3.18.5, there are no nonradiological risks as a result of AOEs in the Electrical System.

9.3.18.6 Corrective Actions

Corrective actions following an AOE in the Electrical System include the repair of system components and the return of the facility to an operational status, as required.

Summary

- A review of the SIRIM reports shows that no major electrical incidents have occurred that either damaged electrical equipment or injured personnel. The only SIRIM reports involving safety are CIF Event 9602c, # 104, and CIF Event 9602d # 236. These reports cover the Ashcrete Hoist Trolley, which showed the chain fall casing to be at 110 VAC. This problem has been referred to Engineering for solution.

- Other lessons learned showed the Electrical System to be functioning as designed. For example:
  1. CIF 9602c, # 26 and CIF 9602d # 57 involved an overload trip for Filter Feed Tank Agitator. The motor was overloaded because of pump packing and a cold gearbox.
  2. CIF 9602c # 53, # 124, # 144 and CIF 9602d # 105, # 190, # 198, # 239 and # 240 all are the result of blown fuses in the PLC Drop # 4, 0515-2 which feeds the Building Sump Pump # 3. Fuses and PLC cards replaced.
  3. CIF 9602c # 122 and # 129 involve the enable/disable controls from the DCS when running in the AUTO mode. Referred to Engineering.
  4. CIF 9602c # 217 involved ROW Feed Pump # 1 starting even if LOW pressure was indicated. Referred to Engineering.
  5. CIF 9602d # 154 involved a loose wire dangling from the Tank Farm cable tray. Stray voltage observed. Cable was taped.